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China's Approach to Technology Acquisition: Part I--The Aircraft Industry

Hans Heymann, Jr.

A Report prepared for

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Rand
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PREFACE

This Report constitutes Part I of a three-part study that addresses the question of how extensively and how effectively the People's Republic of China (PRC) utilizes the great reservoir of technology that is potentially available to it from the most advanced industrial countries. It is part of a larger research program on technology exchange and technology export sponsored by the Defense Advanced Research Projects Agency.

The study is intended as a first cut at the task of understanding China's technology acquisition strategy. It seeks to illuminate the evolution of that strategy over the past twenty-odd years; to discover how the strategy is linked to the process of technology diffusion within China; to gain insight into China's probable present and future rate of high-technology advance, and the degree to which that advance depends upon outside contributions. In a later phase the research will focus on the implications of this strategy for U.S. security policy, particularly as it relates to technology transfer and export control.

The research has concentrated initially on two of China's modernizing industries -- aircraft and automotive. The present Report, Part I of the overall study, deals with the Chinese aircraft industry. It traces the successive stages of the industry's evolution, delineates the foreign contribution to its technological growth, and appraises the rationale and significance of the PRC's recent foreign aeronautical acquisitions as they may affect the industry's future development. A second Report (R-1574), designated Part II, examines the Chinese automotive industry in a parallel fashion, but more briefly and with a focus on its contemporary situation. A third Report (R-1575), Part III of the study, gives a summary assessment of the Chinese technology acquisition process as a whole.

The study's findings should interest those agencies of the U.S. Government principally concerned with strategic export control and technology transfer -- the Office of East-West Trade of the Department of State, the Office of Strategic Trade and Disclosure of the Department of Defense, the Bureau of East-West Trade of the Department of Commerce,

and the Council on International Economic Policy of the Executive Office of the President. The findings should also be useful to those on the staffs of the military services and of the national intelligence community who are concerned with technology assessments.

SUMMARY

AIRCRAFT PRODUCTION

China's aircraft industry is, to a striking degree, a product of the massive Soviet technological assistance of the 1950s. That assistance ran the gamut of industrial arts, from aeronautical education to aircraft production, and from design emulation to the creation of an industrial management system. It stressed *manufacturing* technology, however, and neglected *design* technology. The Chinese worked eagerly and assiduously at absorbing the assistance, but they chafed under the stultifying Soviet tutelage and rebelled against it in the Great Leap Forward of 1958-1960.

During that period, the Chinese leadership increasingly rebuffed foreign expertise and rejected particularly the Soviet model of industrialization. In the aircraft industry, as in other industries, the Chinese plunged into a frenzied campaign for "mass innovation" and independent design adaptation. While the campaign yielded no truly original designs, it at least served to build up Chinese engineering confidence. But, unlike other Chinese industries, which strove to limit their dependence on Soviet assistance, the aircraft industry continued to receive massive Soviet aid, right up to the precipitous Soviet withdrawal in August 1960.

The sudden Soviet pullout was a major disaster for the ambitious Chinese aircraft production and expansion programs then under way. Airframe and engine production on the MiG-17 jet fighter and Mi-4 helicopter and assembly of the MiG-19 interceptor, all just going into high gear, came to a complete halt. The fact that the industry remained in a state of near-paralysis for more than three years cannot be explained purely by the general economic contraction that China experienced in 1960-1961, nor by its technological dependence on the USSR. A major reason lies in the fact that the Chinese, in late 1959, apparently shifted priorities away from general purpose forces and air power toward a forced-draft nuclear weapons and rocket propulsion program.

Aeronautics -- and especially air-breathing propulsion -- thus experienced in the early and mid-1960s a serious setback, from which it never fully recovered.

Relying essentially on their own resources, the Chinese sought to overcome the loss of aeronautical design and engineering skills they had suffered as a result of both the Soviet withdrawal and their own shift of priorities. They established an Aeronautical Engineering Society in 1963 and launched a "design reform campaign" in 1964. The successes they achieved, however, were in manufacturing, not in design technology. MiG-19 production resumed in 1964; but without Soviet guidance and support, progress in the development of China's own production versions of the Tu-16 bomber and MiG-21 fighter was arduous and slow. Production of these began haltingly in 1967 and 1969, respectively, remained modest, and was cut back or suspended around 1972. The turmoil of the Cultural Revolution disrupted production only briefly, but the proletarianizing of education and the denigration of expertise that it fostered further retarded the development of an advanced aeronautical design capability. The Chinese did succeed, in 1969, in introducing into service their first native-designed military aircraft, the F-9, a twin-jet tactical fighter, but it appears to owe much of its airframe origin and perhaps all of its engine design to the Soviet MiG-19.

In short, the Chinese aircraft industry, though perhaps adequate to meet the PRC's most rudimentary military air-power requirements, has advanced only very slowly over the past dozen years. It suffers from a sizable technological gap which it will not be able to close without external assistance.

CIVIL AIRCRAFT ACQUISITIONS

Since the manufacture of modern transport aircraft lies beyond the capabilities of their industry, the Chinese acquired their civil aircraft fleet almost entirely from abroad: in the piston era of the 1950s, largely from the Russians; in the turboprop era of the sixties, both from the Russians and the West; and in the jet era of the seventies, largely from the West.

Until recently, the Chinese required only a very modest fleet to operate their minuscule civil air services -- an average of about thirty-three scheduled domestic flights per day, plus a handful of short-haul international routes to neighboring countries. Since 1971, however, the Chinese have embarked upon a long-term airline expansion program, gradually modernizing their aeronautical system at home and acquiring air traffic rights abroad. They have concluded new bilateral air transport agreements with more than twenty countries, which will permit CAAC, China's national carrier, to show the flag in politically important parts of the world. To meet these expanded requirements, the Chinese have purchased a new fleet of modern jet transports from the West: thirty-five Hawker Siddeley Tridents (to serve the regional and domestic routes) and ten Boeing 707s (for the longer-ranger international routes). Added to the five Ilyushin Il-62s previously purchased from the Russians, the new jet fleet will expand CAAC's payload-carrying capacity at least fivefold by 1976. China has also signed a "preliminary purchase order" for three Anglo-French Concorde supersonic transports. That order -- no more binding than an option -- is unlikely to be consummated, but it holds distinct attractions for the Chinese from both a political and technological point of view.

IMPACT ON TECHNOLOGY

What technological gains, if any, do the Chinese derive from their civil aircraft purchases?

The foreign aircraft and the process of acquiring them have had only a marginal impact on China's own aircraft production technology. The Chinese have been quite diligent in extracting the maximum of technical information from their negotiations with Western manufacturers and from the plant visits, demonstration flights, training courses, and technical documentation provided them. But while this has been useful to them as general education, it has not significantly advanced their own ability to design, adapt, or manufacture. Moreover, no matter how carefully Chinese engineers may have dissected and studied the foreign aircraft they acquired in the sixties, they made no systematic effort to copy-produce them. Prototype copying is an arduous and

sluggish pursuit at best, but where the technological gap between originator and copier is very large, extracting the technology embodied in a sophisticated design, and absorbing it into an unsophisticated industry is often impractical or simply not feasible without a considerable amount of outside assistance. The Chinese rejected such assistance.

China's ambivalence about foreign technology and its insistence upon "self-reliance" stand in sharp contrast to Soviet technology acquisition strategy in the early 1930s at a comparable stage of development. The Russians acquired engineering assistance, production equipment, and technology licenses from the West on a massive scale. Their uninhibited "open arms" approach yielded immediate technological benefits, and Soviet engineers developed great adeptness at copying. Soviet *design* technology, however, evolved only slowly. The Chinese self-protective "arm's length" approach is unlikely to achieve rapid short-run gains. Whether it builds more self-confidence and creativity in the long run is debatable.

Bridging the large technological gap in aircraft production, however, is now both a short- and a long-run necessity for China. By their own assessment, by what is known of the engineering performance of their aircraft, and by what has been reported by foreign pilots who have flown them, the Chinese are roughly twenty years behind the West. This is borne out by the fact that the three aircraft models that may be taken to represent China's current level of production technology -- the MiG-19, MiG-21, and Tu-16 -- first entered into series production in the Soviet Union in the early and mid-fifties. Their propulsion systems are closely comparable in performance to Pratt & Whitney, Curtiss Wright, and General Electric engines that went into service in the United States between 1952 and 1956. Measured against a seven-generation history of turbine engine development, they represent the second and third generation turbo*jet* eras of the early and mid-1950s. This is a considerable technological gap, and from all indications, the Chinese are now seriously concerned about its persistence, particularly in aero-engine production.

NARROWING THE TECHNOLOGICAL GAP

In early 1973, in a significant move, the Chinese opened negotiations with Rolls Royce (1971), Ltd. to obtain extensive technical assistance and unrestricted license production rights for the Spey turbofan engine which, in a civil model, powers the British Trident medium-range and the BAC-111 short-haul transports, and in a military model, the British version of the McDonnell Douglas F-4 Phantom fighter. In terms of its critical performance indicators, the Spey engine falls in the fourth and fifth generation turbo*fan* era of the early 1960s. Acquiring this technology, therefore, would propel the industry approximately ten years forward. To accomplish this would require a considerable Chinese domestic investment and a gestation period of several years. While it would still leave the Chinese at least ten years behind the most advanced high-bypass-ratio turbofans now operational in the West, the ten-year gain could still very significantly help China meet her civil and military needs. The gestation period could be shortened if the Chinese were to permit Rolls Royce to provide a comprehensive assistance package, including an initial flow of engines and a phased, closely cooperative program for transferring the capability to produce them. The benefits of the relationship for the Chinese would be maximized if it continued over many years and encompassed progressively more advanced levels of technology. If, on the other hand, China put a strict construction on its "self-reliance" principle, the scope and significance of the transfer would be severely limited.

Two other areas in which the Chinese aircraft industry appears now to be seeking rapid technical advances are (1) light transports, particularly in the Short Take-Off and Landing (STOL) class and (2) helicopters. Chinese inquiries, plant visits, and recent specialized power plant and helicopter purchases all point to a serious ongoing effort to develop their own STOL, utility, and rotary-wing aircraft production capabilities.

On occasion, over the past two years, the Chinese have shown some interest in possibly purchasing military transport and combat aircraft from the West. Since any such purchase would greatly provoke Soviet anxieties, Chinese feelers have been discreet and tentative. They may have had more to do with explorations and precautionary maneuverings in the Sino-Soviet conflict than with any serious Chinese intent to purchase.

CONTENTS

I. INTRODUCTION

How effectively has the People's Republic of China (PRC) utilized the aeronautical technology of the industrialized countries in developing its own aircraft industry? What measures did it take to enhance its own aeronautical capabilities? What additional gains can it hope to secure from further resort to technology imports? This study seeks to answer these basic questions. It traces the evolution of the Chinese aircraft industry and the benefits derived from Soviet aid; it describes the fleet of transport aircraft that the PRC gradually acquired, almost entirely from abroad, and delineates the domestic and international air routes which that fleet is designed to serve; and it examines the significance of these and other technology acquisitions in advancing China's own design and production capabilities.

KINDS OF TECHNOLOGY

Since the term "technology acquisition" can signify a variety of things, its meaning in this study needs to be clarified. Briefly, the term here encompasses any accretion of technical knowledge or capability, however obtained, that results in an increase in factor productivity (output per man-hour, yield per acre of land, and so forth). Thus it includes any qualitative advance in skill, technique, know-how, production process, equipment, and plant that enhances performance or reduces cost. As used here, therefore, "technology" includes both the *tools* which man creates to help him cope with his environment, and the *techniques* he uses in the production and application of these tools.

For studying China, technology could be subclassified in several ways. In agricultural production, for example, technology might be subdivided into *hydrological*, *biological*, and *mechanical* technologies, according to the class of technical inputs applied (say, water conservancy, improved seeds, tractor power). In industrial production, distinctions could be drawn according to levels of technical complexity, for example, *primitive*, *intermediate*, and *advanced* levels of technology. For this study, which deals principally with modern industry, it may be helpful

to differentiate three aspects of the production system: *manufacturing* technology, *design* technology, and *management* technology.

Manufacturing technology relates most directly to actual physical production -- skills of fabrication, techniques of processing, refinement of materials, and so forth. As we shall argue in the present study, it is in this sphere of "technology of the factory" that the Chinese aircraft industry has probably shown the greatest innovative advance.

Design technology, while still oriented toward production, relates much more closely to the realm of science and engineering; it involves research and development, test and experimentation, professionalism and expertise, all aimed at creating new or improved products, machines, and processes. It might be more properly described as the "technology of the laboratory," and it is an area in which the Chinese leaders have tried hard, by a number of reforms and institutional innovations, to break down the traditional isolation of research from production and to make "the laboratory" truly responsive to "the factory." They have largely succeeded in this, but in doing so they have neglected to nurture a corps of highly qualified experimental development, design, and engineering talent. Hence, as will be pointed out in this Report, at least in the aircraft industry, Chinese design technology remains seriously underdeveloped.

Management technology deals with organizing modern large-scale production -- how much and what kinds of technical specialization and occupational stratification should be permitted; how strong a system of hierarchical authority should be established; what choices between batch-type and assembly-line production should be made; and so forth. In sum, it addresses the question of how to organize a large plant efficiently so as to maximize output and minimize costs, and at the same time motivate and give job satisfaction to the work force. The Chinese have been radically experimental and innovative in this area, but so far have failed to find a satisfactory solution. They continue to wrestle with the nagging problem of tradeoffs: how much should they sacrifice productive efficiency in the interest of "creating the new Maoist man," how much should they encourage mass innovation and foster rank-and-file participation in technical decisionmaking so as to combat bureaucratization and worker

apathy. In trading off between technical-organizational imperatives (economic values) and Maoist social-revolutionary aims (ideological values), Chinese policy has fluctuated widely over the past twenty-five years, with "ideo-logic" holding sway during periods of revolutionary turbulence and "techno-logic" reasserting itself in calmer times. The policy that has now emerged seems to straddle the two sets of values. Calls to revolutionary activism ("criticize Lin, criticize Confucius") now go hand in hand with exhortations to expand production. The current slogan is "grasp the revolution *and* promote production." The twin objectives, however, are not coequal. Where they conflict, the demands of production seem to rank first. But the fight against revisionism continues. The leaders are determined to protect their society from contamination by bourgeois values, and this acts as a persistent constraint upon their willingness to acquire or to adopt the advanced management technologies of the industrialized West.

MODES OF ACQUISITION

The leaders' vigilant stance against alien contamination of Chinese political and economic life also affects their choice of ways of acquiring technology. They view some forms of acquisition as potentially more corrupting than others, and seem to draw a distinction, for example, between *machine*-embodied and *man*-embodied technology. Transferring plant and equipment seems to be regarded as less threatening than transferring people. Thus the importation of foreign equipment, whether for the purpose of end-use or as prototypes for copy-production, seems to cause less apprehension than, say, the importation of foreign experts as advisers or the sending of Chinese abroad for education and training. In the eyes of the leadership, the more intimate the foreign contact and the more extensive the cultural exposure, the greater the threat of contamination. Hence the leadership strives hard to limit and control such exposure. The deliberate self-isolation and clannishness of Chinese technical groups on visits or assignments abroad and the carefully circumscribed access that foreign technicians are permitted on visits or assignments to China clearly testify to this.

Nevertheless, despite their misgivings, the Chinese have had recourse in recent years to the whole spectrum of ways of acquiring technology. These include: the procuring of foreign technical literature; visits by distinguished foreign scientists; the holding of industrial exhibitions in Peking, Shanghai, and Tientsin by major technology-exporting countries; visits to foreign plants by Chinese technical missions; purchase of a wide range of foreign machinery and equipment; acquisition of license rights for foreign processes or for product manufacturing in China; importation of complete industrial plants worth billions of dollars; contracting for foreign technicians to help set up these plants in China; and training Chinese technicians abroad. Notably absent from this list is any form of direct foreign participation in developing China's resources -- joint ventures for exploration, service contracts for onshore or offshore drilling, or the like. Here the ideological line is firmly drawn, and any notion of "relying on foreigners" or "groveling for foreign loans" is vigorously rejected.

REJECTION OF DEPENDENCY

Ever since the late 1950s, when the Chinese leaders reacted against what they saw as excessive reliance on Soviet tutelage, they have pursued -- with varying degrees of intensity -- a policy of relative autarky, extolling the virtues of economic independence and technological self-reliance. This bootstraps approach to economic development, a reaffirmation of a more traditional Chinese nativism and self-assertion, never completely rejected the relevance of foreign technology, but it did greatly downgrade the importance of expertise in general and of foreign expertise in particular. Employing the characteristic "two-line struggle" formulation, a recent authoritative statement* contrasts Chairman Mao's "correct line of maintaining independence, keeping the initiative in our own hands, relying on our own efforts and on arduous struggle, and building our country through diligence and frugality" with the Liu Shao-chi/Lin Piao revisionist line of "worshiping foreign things,

*Tien Chih-sung, "Adhere to the Policy of Independence and Self-Reliance," *Jen-min Jih-pao*, Peking, March 22, 1974 (SCMP-74-14, No. 5584, April 4, 1974).

trumpeting the slavish comprador philosophy, and promoting the mentality of trailing behind at a snail's pace."

While this formulation seems to draw a black and white contrast, the official dictum goes on to point out that the policy of independence and self-reliance "does not mean that we should not introduce foreign technology. The introduction of a bit of foreign technology is permissible . . . [but] we can only use it as reference and must actively catch up with it. We must make discoveries, inventions, and progress. Otherwise we shall always be trailing along at a snail's pace behind other people." China's Minister of Foreign Trade, making the same point in somewhat different words, argues that China engages in foreign trade "to learn from other countries' merits and to obtain necessary materials, equipment, and techniques through exchange. This is putting into practice the principle of making foreign things serve China and combining learning with inventing in order to increase her ability to build socialism independently, with her own initiative and relying on herself to speed up socialist construction."* The Chinese ambivalence toward foreign technology reflected in these statements is a recurrent theme throughout this study.

LIMITS TO RESEARCH

Finally, turning more specifically to the Chinese aircraft industry, we must ask whether there is much we can learn from a long-distance look at that industry.

The aeronautical experience of Mao's China has, from the outset, been overwhelmingly military in nature, i.e., focused almost entirely on creating at least a minimally adequate air arm for the People's Liberation Army. As a sensitive security matter, China's aircraft industry has been shrouded in secrecy, and a reliable technological assessment of it is thus extraordinarily difficult. Nevertheless, a rough measure of China's state of the art in aeronautics can be developed from open sources, largely by analogy. Fortunately for the investigator, all of the aero-engines and all but one of the airframes of Chinese-made

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*Li Chiang, "New Developments in China's Foreign Trade," *China's Foreign Trade*, No. 1, May 1974.

aircraft that have reached the series production stage in the PRC are of Soviet design origin or were produced under Soviet license. Because the Soviet models in question have long since become obsolescent to the Soviet air order of battle, the significant aspects of their development history and their technical characteristics are by now largely in the public domain.* And China's aircraft production system also is essentially of Soviet origin, a product of the massive Soviet technology infusion of the 1950s, which built up the Chinese aircraft industry very much in the Soviet image. This legacy of Soviet-derived aircraft and production plant makes the task of assessment somewhat less intractable. Nevertheless, while we know a good deal about the foreign technology *inputs* into Chinese industry and about the physical characteristics of the *outputs* of the industry, we know very little about the efficiency and effectiveness of the "black box" that converts the inputs into outputs -- the physical plant and its productivity, and the institutional, policy, and decision processes that have led to the particular results we are able to observe. The vast gaps in our knowledge are not likely to be filled until the PRC lifts its heavy veil of secrecy and permits some degree of foreign access to its industry.**

Lacking such access, this study has obtained some of its findings from a sampling, through interviews, of the experiences and assessments

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*See such studies as A. J. Alexander, *R&D in Soviet Aviation*, The Rand Corporation, R-589-PR, November 1970; John A. Parker et al., *Soviet Planning Study No. 4: The Soviet Aircraft Industry*, Institute for Research in Social Science, University of North Carolina, Chapel Hill, 1955; A. S. Yakovlev, *Target of Life*, Moscow, 1966; annual editions of Jane's *All the World's Aircraft*, and the International Institute for Strategic Studies' annual quantitative assessment, *The Military Balance*, as well as various analyses in *Aviation Week* and *Space Technology*.

**To this writer's knowledge, no foreign experts have been permitted to visit a Chinese aircraft plant for at least a dozen years, with the single exception of a small Rolls Royce group that visited the aircraft engine plant at Shenyang in late 1972. Because of a long-standing technical training and export relationship to the Chinese dating back to the early sixties, Rolls Royce, and especially their Technical Director, Dr. Sidney Hooker, now find themselves in a favored position.

of traders and manufacturers in the United States, Canada, Western Europe, and Japan who have had substantial technology trading relationships with China during the 1960s and early 1970s.* These interviews, although a look at China from the outside, proved more informative than might have been expected, considering the arm's length relationship that China has consistently maintained with its external suppliers. There were, however, important limits to what could be obtained from the interviews: (1) Some enterprises, especially in the United States and Canada, had entered the China market so recently that they lacked the familiarity and historic perspective of the more experienced traders; (2) Some had devoted little effort to analyzing or exploring the state of their counterpart industry in China and, therefore, could throw little light on the problem; (3) Almost all interviewees exhibited some degree of reluctance to discuss details of their China trading relationship, either because of an ill-defined apprehension that to "kiss and tell" might displease the PRC's trading organization, or because of sensitivity over their own commercial proprietary position. One or two declined outright to discuss any matters of substance. In most cases reluctance was overcome by not discussing matters under current negotiation, avoiding details of commercial terms and conditions of sale, and strictly adhering to a policy of "no citation, quotation, or attribution." That policy explains the absence in various places of specific references to sources.

But within those limitations, the interviews, reinforced by extensive research in Chinese sources and Western, Japanese, and Soviet writings on China's industrialization policy, have yielded observations and assessments which, though they must still be treated to some extent as hypotheses, may stimulate and focus future investigations.

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*A listing of individuals and institutions interviewed is available from the author on request.

II. DOMESTIC PRODUCTION OF AIRCRAFT

EARLY ORIGINS

China's experience with aircraft production, of course, antedates the Communists' accession to power. As early as 1938, within one year of their invasion of Manchuria, the Japanese had established an aircraft engineering industry there, the Manchu Airplane Manufacturing Company, with plants in Shenyang, Kungchuling, and Harbin. The facilities were modern, employed a work force of close to 10,000, and produced combat aircraft and engines for the Japanese Army. At the end of World War II when Soviet forces overran the Japanese in Manchuria, the Russians systematically stripped these plants of all movable machine tools and equipment (as they did with all major Manchurian industry) and removed them to the Soviet Union as reparations. The buildings and adjoining airfields, however, were left intact and the skilled labor force was not dispersed.* These assets subsequently became the foundation of the PRC's aircraft industry.

The major impetus for the creation of a Chinese aircraft industry derived from the Korean War and its demands for sustained use of air power. During their long struggle against the Kuomintang in the thirties and early forties, Mao's forces had some sporadic experience with Soviet and Western aircraft, but had acquired no air force of their own to speak of, and had little opportunity to use aircraft in action. Their real initiation to military aeronautics came in 1945 when Soviet forces entered Manchuria, captured the Japanese Army's huge stocks of weapons, equipment, supplies, and aircraft, and turned them over to the Chinese Communists. Overnight the new Red Chinese Air Force became the largest air force in northern China. Its proficiency was developed with the help of hundreds of former Manchurian pilots and technicians who signed on as mercenaries and trainers. During the ensuing civil war (1946-1949), much additional training was provided by Japanese and

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*Edwin W. Pauley, *Report on Japanese Assets in Manchuria to the President of the United States, July 1946*, Government Printing Office, Washington, D.C., 1950.

Russian instructors, and the Communist air arm was greatly expanded by the capture or defection of Nationalist crews and aircraft. It was further enhanced in 1949 by the Communists' capture of some 1400 Nationalist aircraft technicians at Shanghai. Later that year, the Chinese People's Liberation Army Air Force (PLAAF) was formally organized.*

Within weeks of the outbreak of the Korean War, PLAAF began to receive the first trickle of Soviet MiG-15 jet fighters and a variety of other combat aircraft types, as well as Soviet training at Shenyang and in the USSR for PLAAF pilots and ground crews. The trickle soon turned into a torrent when the Russians were forced to replace the severe aircraft losses sustained by PLAAF during the Korean fighting.** But this was only the beginning; the great Soviet buildup of PLAAF continued through the mid-fifties and created a Chinese air force of some 4000 aircraft (fighters, tactical and strategic bombers, transports, and support), a complex of training establishments as well as maintenance and overhaul facilities. Since Soviet military assistance was credit- rather than grant-aid, China went deeply into debt.

FIRST FIVE-YEAR PLAN (1952-1957)

In order to reduce these costs and to develop military self-sufficiency, China was determined to acquire her own aircraft industry. Here Soviet assistance was fundamental. Beginning with the first major Sino-Soviet Accord for Technical and Scientific Cooperation, signed in Moscow on September 15, 1953, and subsequently greatly expanded in four follow-on accords,*** the Soviet Union undertook, over a period of seven years, what was surely the most comprehensive technology transfer in modern industrial history. The accords provided for the construction in China of 291 major industrial plants by 1967 with equipment valued at

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*For a detailed history of the development of the PLAAF, see Richard M. Bueschel, *Communist Chinese Air Power*, Praeger, New York, 1968.

**Their combat attrition is estimated to have exceeded 2000 aircraft in the course of the war. (Bueschel, op. cit., p. 26.)

***The later agreements were concluded in October 1954, April 1956, August 1958, and February 1959.

$3.3 billion. The assistance included vast quantities of blueprints, specifications, and standards, some 10,000 Soviet specialists and advisers, and training in the USSR for some 38,000 Chinese technicians, scientists, academic students, and skilled workers.* Of the 291 projects encompassed by the agreements, only 130 (valued at $1.35 billion) had been completed by the time of the Sino-Soviet rupture in mid-1960, but many others were in various stages of completion, and enough had been accomplished to provide the PRC with the essential underpinnings of a modern heavy and defense industry.

Nowhere was Soviet assistance more thorough and systematic than in the creation of China's aircraft industry. Based in the previously looted Manchurian plants, especially those in Shenyang and Harbin, Soviet engineers and technicians completely refurbished the airframe and engine plants with the then most advanced Soviet production equipment and began to develop a highly integrated, progressively self-sufficient aviation industry, complete with metal fabricating and forming plants, component and avionics manufacturing facilities, and aeronautical engineering and associated R&D establishments, all organized along Soviet lines.

In aircraft production, the Soviet technology transfer to China was quite similar -- at least in scope and style -- to the transfers between the United States and Japan that occurred in the late fifties and early sixties. These interfirm transfers were between the Lockheed

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*More detailed descriptions of the nature and scope of Soviet economic assistance to China during this period can be found in A. H. Usack and R. E. Batsavage, "The International Trade of the PRC," *People's Republic of China: An Economic Assessment*, Joint Economic Committee print, May 18, 1972, pp. 335-346; "International Trade of Communist China," *An Economic Profile of Mainland China*, Joint Economic Committee print, February 1967, pp. 583-592; Chu-yuan Cheng, *Scientific and Engineering Manpower in Communist China, 1949-1963*, National Science Foundation Publication No. 65-14, Government Printing Office, Washington, D.C., 1965, pp. 186-217; and Vsevolod Holubnychy, "Soviet Economic Aid to China," *Bulletin of the Institute for the Study of the USSR*, Vol. III, No. 1, January 1956, pp. 3-23. A particularly thoughtful analysis is contained in M. Gardner Clark, *The Development of China's Steel Industry and Soviet Technical Aid*, Cornell University, Ithaca, New York, 1973, Chapters III and IX.

Aircraft Corporation and North American Aviation on the one hand and Mitsubishi Heavy Industries and the Kawasaki Aircraft Company on the other. Just as in the Soviet-to-China case, the U.S.-to-Japan transfers involved a succession of increasingly complex aircraft types, starting with the relatively simple T-33A jet trainer and culminating in the quite sophisticated F-104J interceptor; and they followed a phase-in procedure that began with the mere reassembly by the Japanese licensee of "knockdown" aircraft manufactured and shipped by the U.S. licenser, and led ultimately to completely indigenous production of the entire aircraft by the Japanese.* In the same fashion, the Soviet Union, as early as 1954, when it had restored China's newly-named National Aircraft Factory at Shenyang to some semblance of working order, began to ship the relatively simple Yakovlev Yak-18 primary trainer in "knockdown" form for reassembly at Shenyang. At the same time, the Soviet Ministry of Aviation Industry provided China's Second Ministry of Machinebuilding with the necessary production licenses, engineering drawings, assembly tools, and production tooling to enable the Chinese to progress from assembly of "knockdowns" to production of components, to ultimate assumption of full production responsibility. At Shenyang by 1956, Yak-18 trainers and MiG-15 jet fighters were being at first merely assembled, then co-produced, and ultimately completely self-produced.

Aero-engine production developed similarly. An Institute of Mechanics was established in 1956 within the Chinese Academy of Sciences, under the leadership of Dr. Ch'ien Hsüeh-shen, the famous MIT-trained aerodynamicist who had worked for years under Theodore von Karman at Cal Tech and had returned to China in 1955.** Under his guidance, jet

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*An analytic description of this process is contained in G. R. Hall and R. E. Johnson, *Transfer of United States Aerospace Technology to Japan*, The Rand Corporation, P-3875, July 1968.

**He was only one (though the best known) of a horde of scientist-returnees. According to informed estimates, some 5000 Western-trained Chinese specialists in the fields of nuclear physics and chemistry alone have returned to China from the United States and Europe since 1950. (*Aviation Week and Space Technology*, October 23, 1967, p. 59.)

propulsion technology developed at a dramatic rate in China. The first aero-engines to be domestically produced under Soviet license were the 160-horsepower Shvetsov M-11FR five-cylinder radial engine to power the Yak-18, the 260-hp Ivchenko AI-14R nine-cylinder radial engine as a follow-on, and the 6000-lb-thrust Klimov VK-1 and -1A centrifugal-flow turbojet engines to power the MiG-15 and -17 fighters. By mid-1959 production of the Shenyang MiG-17, equipped with wholly Chinese-built engines, had reached the remarkable rate of twenty-five per month. The first all-Chinese-built civil aircraft entered production at Nanchang in Kiangsi Province in 1958. It was again a Soviet model, the ten-passenger Antonov An-2 biplane, first powered by the Shvetsov 750-hp ASh-21 piston engine, later replaced by an uprated Chinese version of the 1000-hp Soviet ASh-62 radial engine. Production of the An-2 continued over a period of ten years and many hundreds of An-2s were built in passenger, utility, and agricultural versions.

The Soviet assistance embraced much more than merely production technology. It ran the gamut from scientific-technical education to design engineering, and from project-making to the creation of a modern industrial organization, complete with planning, budgeting, and management systems. All of this the Chinese accepted eagerly and meticulously -- until the inevitable revulsion against this total Soviet tutelage that came in the Great Leap Forward.

THE GREAT LEAP FORWARD (1958-1960)

Despite the disruptions and irrationalities of the Great Leap, China's progress in aircraft production continued unabated throughout this turbulent period. Apparently the aircraft industry, as a vital defense industry, was largely insulated from the Maoist-inspired anti-foreign technology campaign that pitted "red" against "expert," and was shielded from the worst consequences of "mass participation" -- the effort to proletarianize the sources of innovation -- that led to widespread irrationalities and violations of technical norms and stress-limits on machinery throughout China. Indeed, for the aircraft industry the last two Sino-Soviet technical cooperation accords, those of

August 1958 and February 1959, were undoubtedly the most productive. They permitted not only the initiation of licensed production of such advanced aircraft as the supersonic MiG-19 with its more advanced Klimov RD9B axial-flow turbojet engine at Shenyang and the Mil Mi-4 "Whirlwind" helicopter with its tried and proven 1700-hp Shvetsov ASh-82V 14-cylinder radial engine at Harbin, but they also provided for large-scale Soviet assistance in the expansion and dispersal of China's aircraft industry deep into the interior of China. Major work was begun in 1959-1960 on the creation of two large new complexes at Sian and Chengtu; these eventually became the production centers for the Chinese version of the Tupolev Tu-16 medium bomber and the MiG-21 fighter, respectively.

In all these efforts, China was thoroughly dependent on Soviet technical guidance. A Chinese writer provides a glimpse of the extent of this guidance:

> For one large rolling and seamless-tube plant designed for us by the Soviet Union, in order to carry out the work, there were required over 20,000 project documents. . . . It must be obvious how much labor was required for the preparation of all the technical documentation . . . prepared for us by the Soviet Union on the basis of experience extending over several decades. China pays only the cost of duplicating the documents. Such a situation seems to be without precedent among capitalist countries.*

The Great Leap syndrome sought to break this sense of dependency by denying the superiority of foreign science and technology, and by encouraging China's students and workers to rely on their own ingenuity and revolutionary zeal to storm all bastions and to solve all problems.

In the sphere of aeronautics, it led to an outpouring of experimentation and "mass innovation." A spate of hand-built aircraft prototypes "of original Chinese design" made their appearance during 1958 and early 1959, constructed in a frenzy of activity by the "students, instructors, and workers" of the various aeronautical institutes and workshops in China. In rapid succession, close to a dozen such designs were unveiled

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*Ming Peng, *Istoriia kitaisko-sovetskoi druzhbi* (History of Sino-Soviet Friendship), translated into Russian by K. F. Kotovoi, Moscow, Izdatel'stvo sotsial'no-ekonomicheskoi literaturi, 1959, pp. 316-317.

in a blaze of self-congratulatory public acclaim. In fact, of course, the prototypes were not original designs, but modest adaptations of Soviet models, powered by standard Soviet engines. The accomplishment was nonetheless striking. Typical examples are:*

- The *Shenyang Chinko No. 1*, "designed and built by the Shenyang Aeronautical Institute in 75 days" (as claimed in the Chinese press), was an almost exact copy of the Soviet Yak-12 general-purpose monoplane, powered by the Shvetsov M-11FR radial engine.
- The *Hiryu No. 1*, constructed by the Feilung (Flying Dragon) Machinebuilding Works in Shanghai "in 48 days," was a seaplane version of the same Yak-12 with the same power plant.
- The *Heilungkiang No. 1*, built by the Harbin Aircraft Engineering College, was an agricultural crop-dusting modification of the same Yak-12. This College also produced a scaled-down version of the Czech Super-Aero 45 light transport "in 82 days."
- The *Yenan No. 1*, created by the Northwestern Technological University at Sian, was another Yak-12 agricultural adaptation, this one powered by the 260-hp Soviet Ivchenko AI-14R radial engine.

The most sophisticated and prolific of the designer-modifiers was the prestigious Peking Institute of Aeronautical Engineering, which gave birth to no less than three models:

- The *Peking Shou-tu (Capital) No. 1*, a scaled-down version of the Antonov An-14, a twin-engine light utility aircraft, again powered by the Shvetsov M-11FR engine, all put together "in 68 days."

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*Data for these examples were drawn from Jane's *All the World's Aircraft, 1961-1962*, London, 1961, pp. 33-34; from Bueschel, op. cit., pp. 43-46, and 123-127; and from Harriett E. Porch, *Civil Aviation in Communist China Since 1949*, The Rand Corporation, RM-4666-1-PR, December 1968, pp. 86-87.

- The *Peking No. 1*, another twin-engine scale-down, this one based on the Soviet Yak-16 passenger transport. It was powered by the Ivchenko AI-14R engine and took "100 days to complete."
- The *Red Banner No. 1*, a high-wing monoplane of uncertain heritage, powered by the same Ivchenko engine.

All of these "forced draft" design modifications were intended to yield pre-production prototypes. However, only one of the models actually went into series production, the Peking No. 1, which entered China's civil airline service in modest numbers during the late fifties and early sixties.

While not particularly original or successful, these feats of high-speed adaptation and improvisation did build up Chinese confidence. They served to demonstrate to China's fledgling aircraft engineers that they could combine theory with practice, link research with production, and do at least some simple forms of aircraft designing essentially on their own. The Great Leap thus greatly reinforced the Chinese tendency toward pragmatism in engineering education. Their aeronautical institutes and engineering colleges all established their own production workshops and pilot plants, or located themselves on the same sites as the aircraft-producing factories. The students and faculty spent at least as much time assembling or producing as they did learning or teaching.

This overwhelmingly utilitarian, production-biased approach to technical education, however, had its serious flaw: It failed to develop the kind of broadly-based theoretic and analytic grounding that is essential to original design and creative engineering. It emphasized manufacturing technology, not design technology. Hence, in aeronautics, as in many other areas, Chinese engineers were ill-prepared for the independent design and development demands that they would face in the 1960s, when the withdrawal of Soviet assistance put them on their own.

Moreover, this deficiency in design technology was accentuated by the emphasis and scope of Soviet engineering training given to the Chinese in the 1950s. That training was very much production-oriented. All levels

of Chinese production personnel benefited from it, from plant manager and chief engineer down to shop foreman and skilled worker.* But with a few exceptions the development of research and design talent was less well served, for in these areas the Chinese were kept more or less at arm's length.** Particularly in the field of aircraft design, cooperation between Soviet and Chinese research and design institutes was strictly at long distance and limited to the transmission of technical data. Chinese engineers and designers, for example, were not invited to visit or participate in the work of the leading Soviet aeronautical research institutes, such as TsAGI and TsIAM,*** nor given direct access to the key Soviet airframe design bureaus (such as that of Mikoyan and Gurevich) or engine design bureaus (such as that of Vladimir Klimov) whose aircraft and engines they were learning to build under license. Perhaps it was in part to overcome this deficiency that the Chinese, in March 1958, set up a Military Science Academy under the Ministry of National Defense to direct defense R&D, including aircraft design. How much help this Academy, and particularly its aeronautical design staff, received from the Soviet Union, and how effective it became as a native center of aeronautical R&D, is not clear. The Academy evidently played a significant role in China's arduous independent design efforts during the 1960s after Soviet withdrawal.† But by all

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*For example, some seven hundred Soviet technicians helped set up, run in, and manage the Changchun automotive complex completed in 1957, and some five hundred Chinese technicians were given training at the Soviet "parent plant," the Likhachev Automobile Factory in Moscow. (Chu-yuan Cheng, op. cit., p. 201.)

**The most notable exception being in the field of nuclear physics, in which a considerable number of Chinese scientists participated very actively for many years in the advanced research program of the Joint Nuclear Research Institute at Dubna, near Moscow (ibid., p. 196).

***Central Aerohydrodynamics Institute and Central Institute of Aircraft Engines.

†Leo A. Orleans, "R&D in Communist China: Mood, Management, and Measurement," *An Economic Profile of Mainland China*, Joint Economic Committee print, February 1967, p. 568; Bueschel, op. cit., pp. 70, 88, 90, 97, and 98.

indications, its establishment was not enough to overcome the inhospitable factors that were at work -- China's traditional ambivalence toward "foreign science,"* the regime's commitment to a course that rejects the necessity of nurturing a scientific-technical elite, its recurrent promotion of revolutionary activism of the masses, and its insistence on "putting politics in command" of all activity. All these could not help but inhibit and retard the development of an independent, science-disciplined, creative aeronautical design community in China -- a default that became quickly apparent when Soviet assistance, management supervision, and technical resources were suddenly withdrawn in the summer of 1960.

THE GREAT CRISIS AND READJUSTMENT (1961-1965)

The Soviet withdrawal hit China's burgeoning aeronautics industry particularly hard. In most other branches of industry, Sino-Soviet cooperation had come under increasing strain ever since the beginning of the Great Leap in 1958 and, as a result, the intimacy and utility of Soviet assistance had declined steadily. But in aeronautics during that period, the Soviet role had, if anything, become even more essential, partly because of the very ambitiousness of the technology transfer programs to which both countries were committed, and partly because the Chinese did not attack or reject Soviet tutelage in aeronautics as they did in most other areas of economic activity.

By 1960, the Chinese aircraft industry had just begun to master the series production of the MiG-17, of the Klimov centrifugal-flow turbojet engine, and of three types of fairly advanced piston engines. It was beginning to turn out its first Mi-4 helicopters. It had launched a major plant expansion program, involving the construction of two large Soviet-designed airframe and engine production complexes in the new industrial centers of Chengtu and Sian. Most important, it had begun to

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*As early as the mid-nineteenth century, Chinese intellectuals struggled with the problem of whether and how Western science could be accommodated within traditional Chinese values. See the "T'i and Yung" controversy in Joseph R. Levenson, *Confucian China and Its Modern Fate: A Trilogy*, University of California Press, Berkeley, 1968, pp. 59-78.

assemble, from Soviet components, the twin jet MiG-19 and was in the throes of trying to learn the production intricacies of its engine, the Klimov axial flow RD-9B. But all of this was taking place under the closest Soviet supervision and with their intimate participation. Soviet support for China's aircraft ambitions appeared to be unequivocal, even to the point of providing the Chinese, in early 1960, with two samples of the Tu-16 medium bomber with its powerful 21,000-lb thrust Mikulin RD-3M engines, for Chinese familiarization, with a view to eventual co-production.*

The sudden Soviet pullout in August 1960 thus was a major disaster for all these hopeful plans and ongoing programs. According to one report,

> The Soviets withdrew 1,390 experts, cancelled 343 contracts, and left 257 scientific and technical projects high and dry. Russian management and technical personnel at the National Aircraft Factory at Shenyang stripped their offices and even took their blueprints with them, leaving the new Shenyang MiG-19 production lines unfinished and inoperative.**

It is hardly surprising that China's airframe and engine production should grind to a halt. What is surprising is that it remained in a state of near-paralysis and disorganization for more than three years, with virtually no aircraft production, except for a trickle of An-2 utility biplanes. How is this to be explained?

One explanation, of course, lies in the cumulative contraction and depression that the Chinese economy as a whole experienced in 1960-1961, brought on by twin disasters: the planning, organizational, and management breakdown resulting from the excesses of the Great Leap, and the agricultural crisis precipitated by two successive bad harvests. These two factors combined to bring the economy -- in Eckstein's words -- "to

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*The transfer, together with some earlier Soviet assistance in roduction technology, proved invaluable to China's subsequent efforts to reproduce its own version of the Tu-16. See below, pp. 19-20.

**Bueschel, op. cit., p. 68.

a state of prostration similar to that produced by war devastation."* However, economic recovery generally was very visible by 1962, and yet, in the aircraft industry, output did not resume until 1964!

Another explanation assumes a still very high degree of Chinese technological dependency and a consequent helplessness when the Soviet umbilical cord was suddenly cut. This could certainly explain an interruption of a year or two, but given the level of independent production capability the Chinese had attained by 1960, they should have been able, with a concentrated effort, to resume output at least of the MiG-17 by 1962.

In the first place, while the Russians did withdraw their technicians and did sharply curtail their flow of new plant and equipment, they did not cut off all supplies. Anxious not to rupture the relationship completely, the Soviet Union continued to provide a stream of critical spare parts and specialized materials to permit normal overhaul and replacement of their installed manufacturing machinery and equipment. Indeed, in 1962, in a remarkable gesture, the Soviet Union provided the Chinese with two or three dozen MiG-21f (NATO designation: Fishbed-C) day fighters with their relatively sophisticated 13,000-lb thrust Tumanskii R-37f afterburner turbojet engines.**

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*Alexander Eckstein, "Economic Growth and Change in China: A Twenty-Year Perspective," *The China Quarterly*, April/June 1973, p. 240.

**Precisely what motivated the Soviet leaders is not clear. One explanation given to the writer somewhat conjecturally by a Soviet official with many years of experience in China during the crucial years of 1958-1963 was that Soviet leaders then were still doing their best to preserve their long-standing close relationship with the PLAAF. Also, they may well have been trying to dissuade the Chinese from a course, on which they seemed to be embarked, of establishing a new technological relationship with Western European countries. The Chinese had signed a contract for six Vickers Viscount 843 turboprops with the British in December 1961 and were actively negotiating in early 1962 with SAAB of Sweden for license production of the J-35B Draken fighter-interceptor, and with AFA of Switzerland over the P-16 Mark III Strike Fighter. These negotiations ultimately came to naught, but may have given the Russians pause. (China's aircraft negotiations are described in Bueschel, op. cit., pp. 69, 206.)

In the second place, although China was not yet able to produce the esoteric metallurgy (specialized steels, aluminum alloys, etc.) required for turbine engine production and could no longer obtain it from the USSR, alternative sources were open to them, particularly Sweden, which is not a party to the multilateral COCOM export controls -- and such imports did in fact occur.

But most persuasive in casting doubt on the thesis that the Chinese were too Soviet-dependent and lacked the technical capacity to get back into production faster than they did is their impressive performance during the same difficult period, in an entirely different field: nuclear research and production. In the face of widespread economic adversity in 1961 and 1962 they managed not only to set up a 25-million electron-volt cyclotron in Peking and a small research-type reactor in Shanghai, but also to establish three major production facilities: a uranium conversion plant, a 600-megawatt plutonium production reactor at Yumen (Kansu) and a quite sizable gaseous diffusion plant near Lanchou (Kansu).* Clearly, neither the great economic crisis nor Soviet withdrawal was permitted to retard this technologically no less sophisticated effort, and one is inclined to the conclusion that their incomparably poorer performance in aeronautics was as much a consequence of conscious resource allocation decisions forced upon them by economic stringencies as it was of technical constraints.

Indeed, a student of Chinese strategic decisionmaking has noted a significant reordering of priorities in China after 1959, a shifting of resources away from general-purpose forces and airpower and vastly increased investment in a forced-draft nuclear weapons program -- a reversal of the strategy of the 1950s.** Significantly, the shift also encompassed a deemphasis of aircraft in favor of missile development and of airbreathing in favor of rocket propulsion. Others have noted the intense competition for resources between air force modernization and general economic growth

*Charles H. Murphy, "Mainland China's Evolving Nuclear Deterrent," *Bulletin of the Atomic Scientists*, January 1972, p. 29.

**William W. Whitson, *The Chinese High Command: A History of Communist Military Politics, 1927-71*, Praeger, New York, 1973, pp. 462-463.

during this same period.* The fact that the Chinese air force lost this competition became quickly apparent during the years 1961-1964, when the PLAAF declined in line strength and operational capability at an alarming rate. Shortages of spares and fuel became endemic, aircraft had to be cannibalized to keep at least part of the force operating, pilots were restricted to less than fifteen hours of flying time per month and, by 1964, morale in the PLAAF had sunk to an all-time low -- a condition that was surely not improved by the removal of all insignia of rank and the loss of the distinctive PLAAF uniform that was decreed on June 1, 1965.**

While aeronautics in the early sixties thus clearly suffered a relative decline compared to the halcyon days of the late fifties, all was not passive. Substantial efforts were evidently mounted to overcome weaknesses, especially in design technology, caused by the Soviet withdrawal. The period between 1961 and 1964 saw a considerable buildup of the formal engineering disciplines and an increase in technicians and skilled workers through a variety of expanded technical training programs. Educational policy shifted back to a pursuit of "quality," emphasizing formal theoretical knowledge, classroom teaching, book learning, and individual achievement.*** In 1963 the China Aeronautical Engineering Society was established under the prestigious leadership of Shen Yuan, Vice President of the Peking Institute of Aeronautical Engineering, with a view to raising the professional status of Chinese aircraft designers and improving their contacts with the international aeronautical community.

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*Franz J. Mogdis, "The Role of the Chinese Communist Air Force in the 1970s," in William W. Whitson (ed.), *The Military and Political Power in China in the 1970s*, Praeger, New York, 1972, p. 257. See also J. G. Godaire, "Communist China's Defense Establishment: Some Economic Implications," in Joint Economic Committee, *An Economic Profile of Mainland China*, February 1967, p. 164.

**A detailed treatment of problems of morale in the Chinese military is provided in Chester Cheng, *The Politics of the Chinese Red Army*, Stanford, Hoover Institute on War, Revolution and Peace, 1966.

***See Susan Shirk, "The 1963 Temporary Work Regulations for Schools," *The China Quarterly*, No. 55, July/September 1973, pp. 513-515.

In early 1964, a new Seventh Ministry of Machinebuilding was created under the then deputy commander of PLAAF, Wang Pin-cheng, to assume overall planning and management of aircraft production throughout China.*

The year 1964 also saw the initiation by the Chinese leadership of a "design reform campaign" that sought to remedy the shortcomings of Chinese industrial designers.** The campaign focused at first primarily on the capital construction industries, where Chinese designers seemed to be complete captives of their former Soviet mentors, mechanically copying Soviet designs and favoring the large-scale, integrated installations so characteristic of the Soviet model, but by then recognized as being largely inappropriate to Chinese conditions. Also, following the guidelines of their rather formalistic Soviet training, Chinese designers had grown to accept a very narrow definition of their function. To them, plant designing meant passively accepting the desired performance and productivity data supplied them, and, on the basis of these data, turning out the necessary engineering drawings and blueprints, relying heavily for guidance on certain standardized design handbooks and reference tomes. Their responsibility did not extend beyond this to the implementation stage. The reform campaign set out to redefine the design function so as to make the designer himself responsible for collecting the needed data and for the engineering stages before and after the preparation of blueprints. In other words, he was booted out of his ivory tower down to the production site, where he was expected to assume responsibility both for the feasibility and for the success of his designs.

The reform campaign was soon extended beyond plant design to product design as well. In aircraft designing the reformers must have found the

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*Three other new machinebuilding ministries, the Fourth, Fifth, and Sixth, were established during the same period (late 1963-early 1964), to be responsible for such specialized areas as telecommunications and electronics (Bueschel, op. cit., pp. 71-72).

**For a detailed examination of this campaign, see Genevieve Dean, "A Note on the Sources of Technological Innovation in the PRC," in C. Cooper (ed.), *Science Technology and Development*, Frank Cass, London, 1973, pp. 187ff.

need especially great. The general underdevelopment of Chinese design talent described earlier* was aggravated by having inherited the peculiar Soviet R&D system, under which design teams depend heavily on the work of the specialized aviation research institutes (TsAGI, TsIAM, etc.). These institutes enjoy a virtual monopoly on the sophisticated test rigs, wind tunnels, and qualified scientists necessary to carry out advanced design, testing, and experimentation. They convey their research results to the design bureaus largely in the form of "designers' handbooks" which set forth approved structures, recommended aerodynamic forms, sanctioned materials, and tried-and-proven manufacturing techniques.** Chinese aircraft designers had evidently become totally dependent on this kind of crutch and the design reform campaign had to try not only to break this long-standing dependence, but also to overcome an almost total lack of indigenous Chinese experience in research, testing, and experimentation.

At the same time as the design reform campaign was in full swing, aircraft production was once again pushed under a "five-year program of self-reliance" that began in 1964.

MiG-19 production was resumed in that year at Shenyang, but now the aircraft were no longer assembled from Soviet components, but were wholly Chinese-manufactured under the Chinese designation "F-6." Production rates went up rapidly year by year, so that, by 1965, China was able to export a few, and by 1966, several dozen, MiG-19/F-6s to Pakistan and Albania.***

Moreover, work now began in earnest on learning to copy-manufacture the Tupolev Tu-16 medium bomber with its high-thrust Mikulin turbojet

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*See above, pp. 12-14.

**For a more complete description of the Soviet aircraft acquisition process, see Arthur J. Alexander, *R&D in Soviet Aviation*, The Rand Corporation, R-589-PR, November 1970, especially pp. 11-16.

***China had begun exporting aircraft (mostly MiG-15s and MiG-17s) in the early sixties to reequip the North Korean Air Force, and to build up Hanoi's almost nonexistent air arm. But those were drawn not from current production but from the PLAAF's own aircraft inventory (Bueschel, op. cit., pp. 81-86). The export of Chinese-manufactured MiG-19/F-6s has continued sporadically, with a major interruption during the years of the Cultural Revolution. The Pakistani Air Force has been by far the principal

engines. Two samples of this aircraft had been provided to China by the Russians in 1960, but by 1964, when China successfully detonated its first atomic device, the need for a manned nuclear weapons delivery system must have made production of this aircraft a high-priority objective. Without Soviet participation and guidance to help them, it took the Chinese until 1967 to turn out their first all-Chinese produced Tu-16 pre-production prototype. Its output has proceeded at a snail's pace since then, at a rate of perhaps one or two per month, with a cumulative total currently of up to 100 in the force.*

Work got under way during this same period on learning to produce the Mach 2.2 MiG-21, which the Russians had made available to the PLAAF in significant numbers in 1962. Because of its relatively sophisticated Tumanskii turbojet engine, this proved to be an even more difficult task than mastering the Tu-16. Although prototype or trial production may have begun as early as 1966,** actual series production did not get started until 1969, and then only in very small numbers. The learning process was no doubt helped along in 1966 by being able to examine and dissect an advanced all-weather version of this fighter, the MiG-21 Pf (NATO designation: Fishbed-D), procured by diverting a few samples of this model from the Soviet arms supply pipeline to North Vietnam which, at the time, crossed China by railroad.*** According to knowledgeable European observers, the R-37f turbojet engine, though by international standards only a mid-1950s generation† power plant of relatively modest efficiency as regards thrust-to-weight ratio and specific fuel consumption, was nevertheless a quite sophisticated, high-performance engine for its time, with a complex high-pressure ratio dual rotor

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recipient, with seven squadrons of MiG-19/F-6s (112 aircraft) now in their inventory (IISS, op. cit., *Air Force Magazine*, December 1973, p. 108). In May 1972 it was reported that China would supply Pakistan with 100 more MiGs, presumably largely as replacements (*Business International*, December 21, 1973, p. 408).

*IISS, *The Military Balance, 1973-74*, as pre-published in *Air Force Magazine*, December 1973, p. 102.

**Bueschel, op. cit., p. 89.

***Ibid., pp. 90-91, 152-153.

†The "generational" lineage of Chinese turbine engines is discussed more fully in Section IV (see pp. 55-57).

compressor. Manufacture of this engine must have posed a formidable challenge for the Chinese, given the still primitive metal-forming technology (forging, extrusion, precision-casting) and materials technology (high quality aluminum alloys, refractory metals, specialized steels) then at their command. Also during this period the Chinese were engaged in an intense and high priority pursuit of rocket propulsion technology for their missile development program. (They began intensive test firing of their own version of the Soviet SS-4 Sandal MRBM as early as 1965 and used it to deliver a 10-20 KT atomic warhead in their fourth nuclear weapons test in October 1966.)* That activity was clearly in direct competition with the evidently lower priority of the aircraft industry's air-breathing propulsion effort and thus placed a heavy drain on China's limited pool of advanced propulsion design and engineering talent. Indeed, according to one report, the Chinese Military Science Academy is said to have made some efforts to replenish this pool by sending recruiting teams to Western Europe in 1966 and 1967, offering lucrative contracts to experienced German aircraft designers and technicians facing loss of employment in Europe, and to German rocket experts returning from work on the UAR's missile program in Egypt.** This writer, however, has found no supporting evidence that such a recruitment drive ever took place. Whether it would have met with much success in the face of the militant Red Guard anti-foreign campaign, just then getting into full swing in China's Cultural Revolution, is highly dubious.

THE CULTURAL REVOLUTION (1966-1969)

Unlike the period of the Great Leap, which had left the aircraft industry relatively unscathed, the Great Proletarian Cultural Revolution with its Red Guard invasions of factories, its ideological remolding processes, and its chaotic impact on the bureaucracy and on economic

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*Charles H. Murphy, "Mainland China's Evolving Nuclear Deterrent," *Bulletin of the Atomic Scientists*, January 1972, pp. 30-31.

**Bueschel (op. cit., p. 98).

planning could not help but disrupt both production and R&D in all branches of industry.* Work stoppages, transportation breakdowns, and factory shutdowns afflicted even the aeronautical sector, in both production and R&D. In February 1967 the accumulating effects of the turmoil led the Standing Committee of the Party's Central Committee and the Party's Military Affairs Committee to forbid the "exchange of revolutionary experience" in scientific research organs, in the Seventh Machinebuilding Ministry (the ministry then in charge of aircraft production), and in national defense industrial construction units. But these and other repeated admonitions had little effect. Between February 1967 and the summer of 1968, there were numerous reports of political turmoil and upheaval in the Seventh Machinebuilding Ministry and in the Academy of Sciences. In some instances production and research activities were so seriously disrupted that the People's Liberation Army was sent in to restore order.**

It is all the more remarkable that China's aeronautical industry managed nevertheless to make significant progress during this period. As already indicated, the MiG-21 began to be series-produced in 1969, allegedly under the Chinese designation "F-7" and, in the same year, a new twin-jet tactical fighter or fighter-bomber, the F-9 -- though it bears some resemblance to the MiG-19 and probably employs the same RD-9B engine, the F-9 is China's first major native design -- also entered quantity production. Knowledgeable Western observers know relatively little about this aircraft, but it is believed to be primarily intended for the ground-support mission, for which neither the

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*The nuclear weapons program was proably the unique exception, judging purely by its remarkable performance: three weapons tests in 1966, two in 1967, one in 1968, two in 1969 (see J. G. Godaire, op. cit., p. 212; Charles H. Murphy, op. cit., p. 30).

**For more detailed discussions of these tumultuous events, see Bruce J. Esposito, "Science in Mainland China," *Bulletin of the Atomic Scientists*, January 1972, pp. 36-40; also Genevieve Dean and Manfredo Macioti, "Scientific Institutions in China," *Minerva*, Vol. XI, No. 3, July 1973, pp. 318-334.

MiG-19 nor the MiG-21 is suitable. Like the MiG-19, the F-9 is probably capable of operation up to about Mach 1.6. By 1973, up to 300 F-9s are estimated to have entered PLAAF service.*

In short, the Cultural Revolution did not succeed in paralyzing the aircraft industry, though it could not help but retard the development of sophisticated aeronautical engineering talent. The renewed "revolutionizing" of education, the closing of institutions of higher learning for more than two years, the denigration once again of theory in favor of practical application, and the sharp falloff in international scientific and technological contact must have had a depressive effect on the development of precisely those design technology skills which, in China, have been chronically in short supply.

AFTER THE CULTURAL REVOLUTION (1970 TO THE PRESENT)

Whatever retardations and disruptions the Cultural Revolution inflicted on Chinese aeronautics were probably of short duration. By 1969, the ideological fervor of Maoist radicalism had subsided, and more conservative, economically rational policies began once again to be pursued. Military aircraft production rose sharply during the period 1969-1971, only to be cut back even more sharply in 1972.** It has continued at a modest rate since then, but has been limited to the few models and types already described.

It may be well at this point to recapitulate the chronology of China's aircraft production experience to date. Table 1 shows, for each aircraft type, the significant dates of initial acquisition, first assembly from imported components, first native production, and first export. What is currently taking place in the way of more advanced aircraft design and engine development is unfortunately not known to the outside

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*IISS, op. cit., p. 102.

**CIA estimates a reduction in overall military procurement of almost 20 percent, "primarily as a result of a cutback in aircraft production." (Testimony of Director of Central Intelligence William E. Colby before the Joint Economic Committee -- see *Hearings*, Executive Session, April 12, 1974, Committee Print No. 32-730, p. 77.)

Table 1

EVOLUTION OF CHINESE AIRCRAFT PRODUCTION:
FROM SOVIET TUTELAGE TO INDEPENDENCE
(by year)

Aircraft Type (Soviet Designation)	1st Import from USSR	1st Assembly in China[a]	1st All-Chinese Production	Production Stopped or Interrupted	1st Export from China[b]
MiG-15 jet fighter	1950	1956	1958	1960	--
Yak-18 primary trainer	1953	1954	1959	1960-64	--
MiG-17 jet fighter	1954	1956	1959	1960	1965
An-2 utility	1954	1957	1959	1960-62	1965
Mi-4 helicopter	1954	1958	1959	1960-64	1969
MiG-19/F-6 jet fighter	1958	1959	1964	--	1965
Tu-16 medium bomber	1960[c]	--	1967	(e)	--
MiG-21 jet fighter	1962[c]	--	1969	(e)	1970
F-9 fighter bomber[d]	--	--	1969	--	--

[a]Assembled under license from Soviet-furnished components.

[b]Exported principally to Pakistan and North Korea; smaller numbers to North Vietnam and Cambodia; a few MiG-21s to Albania.

[c]Imported *without* blueprints, tooling, or co-production licenses.

[d]All-native Chinese design, larger than, but evidently derived from, MiG-19.

[e]Production may have been suspended around 1972.

world,* but the table as well as other indications point to a rather halting rate of technical advance in the last dozen years. China's major initiative since 1971 has been to turn to the West for the procurement of modern jet transports and to negotiate for the acquisition of modern turbine engine technology; this development suggests a Chinese awareness of a serious technological gap which they may now be seeking to bridge, or perhaps even to close.

To determine just how big this gap is, and how the Chinese are using, or might use foreign technology to help close it, we must turn to the civil side of aviation, where all the more recent technology imports have taken place.

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*That an active aircraft development effort is currently under way in China is beyond question. Their recent purchases in the West of specialized turbine engines (see pp. 66-67 below) and scattered reports of other sorts clearly testify to this. But in the absence of more specific evidence, we can only conjecture that the Chinese aircraft design groups, research institutes, and factory trial production teams that previously devoted themselves to prototype copying and modest adaptations of foreign designs to Chinese needs are now increasingly turning their attention to the development of more advanced, increasingly "native" Chinese designs. What will emerge from these efforts, however, is a matter of pure speculation. (For what it is worth, *Newsweek*, August 12, 1974, p. 8, reports the existence in prototype of a new Chinese delta-wing Mach 2.5 fighter.)

III. ACQUISITION OF A CIVIL AIRCRAFT FLEET

If China's aircraft *production* has been almost entirely military-oriented, its foreign aircraft *acquisition*, at least since the early 1960s, have been civilian in nature -- aimed almost solely at creating a modest civil air-transport fleet. In the past three years, these acquisitions have increased dramatically. In order to understand the rationale of these acquisitions and to assess their significance for China's design and manufacturing technology, we must look briefly at China's civil aviation development and the evolution of the aircraft fleet that serves it.*

DEVELOPMENT OF CIVIL AVIATION

Until quite recently, civil aviation has been given a very low priority within China's relatively underdeveloped transportation system, a predominantly rail-oriented system, with road and water transport playing important subsidiary roles. Air transportation never played more than a trivial role as a mode of passenger transportation. Nevertheless, China's civil aviation has gradually evolved a domestic trunk route system that is quite far flung (see Fig. 1), serving about 70 cities, plus some 35-40 points on local feeder routes. Altogether, the system now covers an unduplicated route mileage of about 42,500. But for the most part it operates along these routes at frequencies of only once or twice a week and consequently has only about 230 flight itineraries per week.** In other words, on an average day the Chinese airline,

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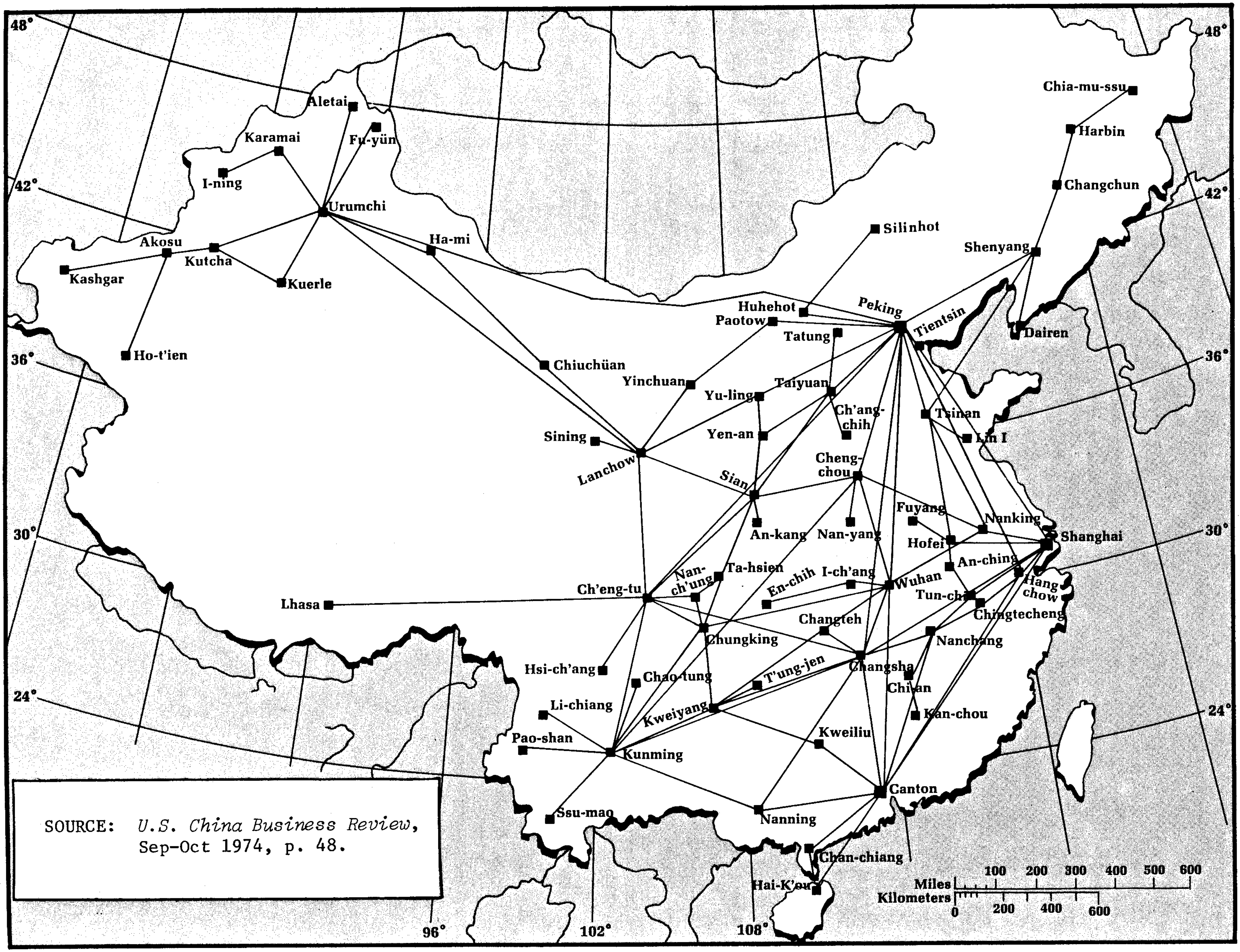
*For a more detailed treatment, see H. Heymann, Jr., "China's Air Transport Industry," in William W. Whitson (ed.), *Doing Business with China: American Trade Opportunities in the 1970s*, Praeger, New York, 1974, pp. 151ff.

**On the basis of recent NCNA reports, the civil air passenger volume carried in 1973 can be calculated at 270 million passenger/miles, and that of civil air freight at 15.2 million ton/miles. By way of comparison, revenue passenger miles of U.S. carriers in 1973 were well in excess of 150 *billion*.



SOURCE: *U.S. China Business Review*, Sep-Oct 1974, p. 48.

Fig. 1 -- China's domestic air routes, April 1974

CAAC,* operates fewer than 33 scheduled flights throughout the whole of that huge, populous country. By way of comparison, India, with a much smaller but similarly densely populated territory, operates more than 80 domestic flights a day; to say nothing of the United States, whose airlines average some 15,000 daily flights in domestic service alone, and whose busiest airport, Chicago's O'Hare, in 1973 handled more than 1,800 aircraft arrivals and departures on an average day. Moreover, China will not find it easy to enlarge its rudimentary airline services quickly, since it is burdened with an airfield complex that generally lacks the runway lengths and other facilities (navaids, control towers, runway lighting, and so forth) required for nighttime and all-weather operations. But some modernization and expansion of domestic operations is clearly in the offing.**

Internationally, China's air links are even more limited; they have, until 1974, been confined to only four cities, all located just beyond its borders: Irkutsk, USSR; Pyongyang, North Korea; Hanoi, North Vietnam; and Rangoon, Burma (see Fig. 2).*** But it is in international aviation where some drastic changes are now occurring. Within the past three years, the PRC's civil aeronautical authority has engaged in a far-flung campaign to acquire the traffic rights necessary for CAAC's major entry into international air carriage. Some two dozen bilateral air transport agreements have been concluded with key governments in Europe, East Africa, Western Asia, and the Pacific. Their purpose is to permit the Chinese carrier to show its flag on politically

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*CAAC is the internationally accepted acronym for Civil Aviation General Administration of China, which combines the functions of national aeronautical authority, national air carrier, and national airport operator.

**Only three of China's civil airports -- Peking, Shanghai, and Canton -- have been developed to international standards, but important improvements are under way. In the fall of 1974, the British Plessey Co. will deliver nine instrument landing systems to CAAC, which will permit all-weather operations at the above three airports, and Category 2 weather operations at six more.

***A synopsis of the development of these routes is given in Appendix Table A-1.

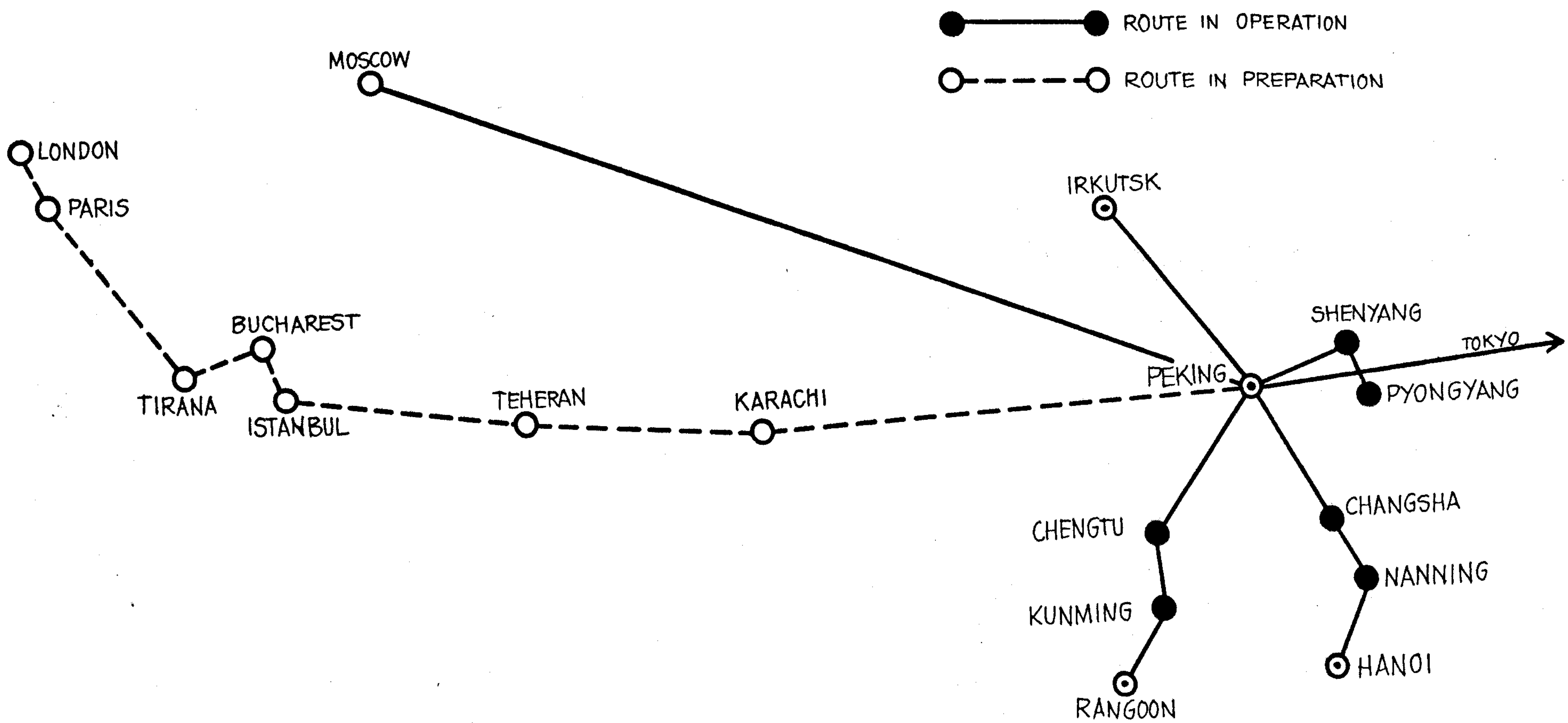

Fig. 2 -- CAAC international routes as of September 1974

important international routes, and thus gain worldwide visibility and national prestige.*

The most important of these routes is in the process of being inaugurated by CAAC. It connects Peking with Eastern and Western Europe, by way of Western Sinkiang, the Karakoram range, Pakistan, Afghanistan, Iran, and Turkey. Although initially to be operated as a one-stop Peking-Karachi-Paris service, its possible destinations in Europe include Belgrade, Bucharest, Tirana, Rome, Geneva, and London. Under the numerous bilateral air agreements it has negotiated, the PRC has already obtained all of the traffic and technical rights required for this route and for its future extension to the Middle East and East Africa. Additional agreements recently concluded, such as with the Scandinavian and Greek governments, further expand CAAC's European rights.

The rate at which these numerous rights are being implemented, however, has for a variety of reasons been very slow. This can be seen, for example, in China's ambitions for a trans-Pacific route. A bilateral air-transport agreement with Canada, in the works for almost two years, was finally signed in mid-1973. It grants CP Air a route into Peking and Shanghai in exchange for a CAAC route to Vancouver and Ottawa with "beyond rights" to other points in the Western Hemisphere. Opening this route had been delayed by Chinese stalling and also by Japan's refusal to grant CP Air either the right to transit through its air space or beyond rights in Tokyo on routes to China. Japan's position on this, however, can be expected to soften now that the recent bilateral between China and Japan is being implemented. This bilateral provides not only for an exchange of routes between Peking and Tokyo, but also beyond rights for each carrier in the other's capital.** This agreement was signed in April 1974, after almost two years of parrying

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*A chronological listing of the routes and rights CAAC has acquired under its air agreements is shown in Appendix Table A-2, and a similar listing of the routes the PRC has granted reciprocally to foreign carriers is shown in Appendix Table A-3.

**CAAC, beyond Tokyo, is to implement its route across the Pacific, and Japan Airlines, beyond Peking, is to link up its Pacific with its European services.

over China's demand that Japan denounce its bilateral with Taiwan as the price for the bilateral with China. It was finally agreed that the Japan-Taiwan air operations be carefully separated from those between Japan and China -- a separation that was, however, anathema to Taiwan, which promptly denounced its bilateral with Japan. The Tokyo-Peking air service was finally inaugurated with much fanfare on September 29, 1974.

Finally, in January 1974, CAAC replaced its once-weekly Peking-Irkutsk route by a direct non-stop route to Moscow. It has had this authority under its 1954 bilateral with the USSR, as amended in December 1962 and in April 1966 but only Aeroflot operated the route, while CAAC aircraft flew only as far as Irkutsk. To complete the arrangements, a CAAC delegation visited Moscow in March 1973 and an Aeroflot team visited Peking in November 1973.

It thus appears that the PRC has made a substantial diplomatic investment to establish international air-transport relations and to acquire traffic rights so that its national carrier can show the flag in numerous countries which the PRC deems politically important. Commercially, of course, none of the long, thin routes are likely to be profitable, given China's very limited traffic-generating potential and the number of international carriers that are now, and will increasingly be, operating on these routes. It is the intangible political rewards, rather than the more tangible financial revenues, that China seeks. But to achieve even these, China must acquire more modern equipment than she now has at her disposal. The recent Western jet aircraft acquisitions must be seen in this light.

EVOLUTION OF THE CIVIL AIRCRAFT FLEET

China's air transport fleet has evolved in three distinct acquisition phases: the piston engine decade of the fifties; the turboprop decade of the sixties; and the turbojet phase of the seventies. Table 2 summarizes this evolution.

The Piston Engine Decade -- The backbone of CAAC's domestic airline fleet is the now truly obsolescent but still serviceable single or

Table 2

EVOLUTION OF CAAC'S CIVIL AIRCRAFT FLEET, 1950-SEPTEMBER 1974

Aircraft	No. Acquired /Ordered	Date Delivered	No. of Passen- gers	Gross Weight (lbs)	Max. Speed (mph)	Engine: No., Designation, Maximum Power	Remarks
<u>Piston Era</u>							
An-2	300[a]	1955-65	7-10	12,127	159	1xASh-62IR, 1000-hp	Soviet-designed utility biplane
Li-2	28	1950s	25		(Soviet	version of Douglas DC-3)	
Il-12	5	1950s	27	38,000	252	2xASh-82FNV, 1850 hp	Resembles Convair 240
Il-14	30	1950s	32	36,400	200	2xASh-82T, 1900 hp	Resembles Convair 340
Peking No. 1	50	1958-60	8-10	6,600	186	2xAI-14R, 260 hp	Chinese version of Yak-16
<u>Turboprop Era</u>							
Il-18	14	1960-67	84-110	134,600	425	4xAI-20K, 4000 shp	Resembles Lockheed Electra
Viscount 843	6	1963-64	56-74	72,500	380	4xRR Dart, 3000 shp	
HPR7 Herald 200	2	1965	45-56	44,000	310	2xRR Dart, 2020 shp	Resembles Fairchild F-27
An-24	8	1965-72	24-50	46,300	335	2xAI-24A, 2550 shp	Resembles Fairchild F-27
<u>Jet Era</u>							
Il-62	5	1971-72	122-186	347,100	560	4xNK8-4, 23,000-lb thrust	Resembles British VC-10
Trident 1[b]	4	1970	109	117,000	610	3xRR Spey RB163-1	
Trident 2E	33	1972-77	112	145,500	612	3xRR Spey RB163-25	1st delivery Nov 1972, 9 by Sept 1974
Super Trident 3B	2	1974-75	152	158,500	590	3xRR Spey 512+IRR RB162 booster	
Boeing 707-320[c]	10	1973-74	189	336,000	600+	4xP+WA JT3D-3B	All 10 delivered by May 1974
British-French Concorde SST	3	1976-77	108-128	385,800	M.2	4xRR Olympus 593 MK62	"Preliminary Purchase Agree- ment" only

[a]About 100 aircraft in passenger version, 200 in agricultural version.

[b]Used aircraft purchased from Pakistan International Airways -- one crashed in Mongolia in September 1971.

[c]Four 320Bs and six 320C convertible transports.

twin-engine piston aircraft imported or derived from the Soviet Union in the 1950s. The largest of these is the Ilyushin Il-14, a twin-engine 32-passenger piston aircraft resembling the Convair 340 or the Martin 404. The smallest, but most popular, is the Antonov An-2, the general purpose metal biplane first purchased from the USSR, then produced in China. It is used by both the specialized agricultural services and the air transport branches of CAAC. The other Chinese-built aircraft in this category is the Peking No. 1 previously described, a design product of the Peking Institute of Aeronautical Engineering during the period of the Great Leap. Some fifty of these aircraft may have been placed in service in 1958-1960.

The Turboprop Decade -- Beginning in late 1959, CAAC took delivery of five Ilyushin Il-18 four-engine turboprop transports from the USSR, after more than a year's pilot, crew, and mechanic training in Moscow. The Il-18 performed poorly, largely because of the widely-publicized design deficiencies in the original 4,000 hp Kuznetsov NK4 engine. Most of these deficiencies were eliminated in a major Soviet redesign effort in 1963 and an improved engine, the Ivchenko AI-20K, was retrofitted that year. At least nine more of these turboprops entered CAAC service between 1963 and 1967, and they continue to operate on CAAC's more heavily traveled and longer-distance domestic and international routes, such as Peking-Canton and Peking-Irkutsk runs. At least one Il-18 was purchased for the PLAAF and used extensively as a VIP transport for visits abroad of PRC dignitaries.* The first two samples of a much smaller turboprop, the Antonov An-24, were also purchased during this period (in 1964), with a follow-on order for six more in 1971.

The significant break with exclusive reliance upon Soviet aircraft, however, came at a much earlier point in the "turboprop decade," when China turned to Britain. Interestingly, the Chinese had begun discussions with Vickers-Armstrong (Aircraft) Ltd. about possible purchase of the memorably successful Viscount four-engine turboprop as

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*Bueschel, op. cit., p. 133.

early as 1959. Negotiations began in earnest in January 1961 but dragged on for almost a year. A contract was finally concluded in December 1961 for six Viscount 843s -- $5.6 million for the aircraft and an additional $4 million for spare engines and parts. Twenty Chinese technicians were trained at the Vickers plant at Weybridge in 1963, and the first Viscount was turned over to a CAAC crew in Hong Kong in July of that year. The Viscounts became the real work-horse on medium- to long-range domestic routes.

When Soviet civil aircraft and spares deliveries declined sharply in the early 1960s (they were to spurt equally sharply in the mid-sixties, only to fall off again during the Cultural Revolution -- see Table 3), Chinese interest in Western aircraft became intense. They made their initial Viscount purchase in 1961. At the 1961 Farnborough show, they carefully evaluated the Vickers VC-10 long-range jet as well as the smaller BAC-111. They engaged in lengthy discussions on the possible purchase of used BOAC Bristol Britannia 102 airliners, even test-flying a demonstration aircraft in England. In the fall of 1963 they turned to France and gave serious consideration to the Sud-Aviation Caravelle SE-210. Shortly thereafter, the British Comet came under Chinese scrutiny, and in 1965 a Dutch trade mission demonstrated the Fokker F-27 in Peking. All of these invitations, discussions, and negotiations, however, came to naught; the only Chinese purchase was a token one, two Herald 200 short-haul turboprop transports from the British Handley Page Company in June 1965.

Vigorous U.S. objections to all of these sales and potential sales are usually cited as the reason why most of the Chinese approaches failed; and indeed, the U.S. made strong diplomatic representations, if not threats, in an effort to block the sales, out of fear that the Chinese would divert these civil aircraft to military use. But the Viscount and Herald sales were concluded in spite of U.S. objections and, according to knowledgeable Europeans, many of the other sales negotiations fell through because the Chinese lost interest or were indecisive rather than because American pressures made the Europeans reluctant to sell.

Table 3

SOVIET EXPORTS OF CIVIL AIR TRANSPORT EQUIPMENT TO CHINA, 1962-1973

Year	Million Rubles	Million U.S. Dollars
1962	1.8	2.0
1963	2.2	2.4
1964	17.6	19.4
1965	12.4	13.6
1966	13.0	14.3
1967	9.7	10.7
1968	1.8	2.0
1969	4.7	5.2
1970	4.3	4.7
1971	30.4	33.4
1972	44.2	48.6
1973	41.6	56.2

SOURCE: Soviet foreign trade statistics, as published annually in *Vneshnaia torgovlia SSSR za* [1962, 1963...etc.] *god*, Moscow, Vneshtorgizdat [1963, 1964...etc.]. The official Soviet statistical category to which those data refer is "193: sredstva vozdushnogo soobshcheniia" -- literally, "air transportation means." It includes transport aircraft, aeroengines, transport helicopters, and their accessories and parts. It evidently *excludes* combat aircraft, engines, and parts.

The conversion of rubles to dollars for the years 1962 through 1972 is made on the basis of the official exchange rate of 1.1 dollar to the ruble established by the USSR on January 1, 1961; for 1973, with fluctuating exchange rates, an estimated average rate of 1.35 dollar to the ruble is used.

With the outbreak of the Cultural Revolution in 1966, China's interest in acquiring foreign aircraft fell off quickly. Only one significant purchase was made between 1966 and 1970: in 1966 France was rewarded for opening diplomatic relations with the PRC by receiving a contract, signed in March 1967, for 15 Aerospatiale Alouette III helicopters, with their 570 shp Turbomeca Artouste 3B turboshaft engines.

Aside from that purchase, foreign acquisitions, both from Europe and from the Soviet Union, came to a virtual standstill.

The Jet Era -- When the Cultural Revolution-induced inhibitions about foreign technology began to wear off in late 1969, Chinese interest in aircraft purchases rather suddenly revived. A policy decision had evidently been made to undertake a long-delayed modernization of the civil aircraft fleet. The PRC acquired its first pure jet transport in early 1970, when an order was placed with the Soviet Ministry of Aviation Industry for five Ilyushin Il-62s, sturdy, though somewhat overdesigned four-engine long-range transports resembling the British VC-10. Two of these were delivered in 1971, the remaining three in early 1972. Some were placed in service on CAAC's most heavily traveled long-haul domestic routes, such as Peking-Canton, previously served only by Il-18 turboprops. Others have been used for VIP flights abroad and on trial runs over CAAC's prospective European route. That route, however, will be serviced by the more recently purchased Boeing 707-320s; the Il-62s will doubtless be used on CAAC's projected weekly Peking-Moscow run.

In 1970, at the same time that CAAC placed its Soviet order, it acquired four used Hawker Siddeley HS-121 Trident 1 jet transports from Pakistan International Airlines (PIA).* The Chinese had been eyeing this medium-range aircraft, powered by three Rolls Royce Spey engines, ever since they first saw a display model at the British Industrial Exhibition in Peking in November 1964, and Hawker Siddeley had sought to keep their interest alive. The Trident purchase from PIA seemed to break the log jam, for CAAC agreed to begin talks in earnest with Hawker Siddeley in early 1971, and after six months of negotiations and the

*There is no indication that these four were ever placed in regular commercial service. They appear to have been put under PLAAF control and reserved for use by high-ranking government officials. It was one of these aircraft that crashed in Mongolia on September 12, 1971, reportedly carrying to their death Chairman Mao's heir-designate Marshal Lin Piao and other members of the Chinese High Command who, according to Chou En-lai, were fleeing to the USSR after an unsuccessful attempted coup.

transmission to China of more than a ton of technical documentation, the Chinese signed a contract for six Trident 2Es in August 1971 for a cash price of about $46 million. Exactly one year later, in August 1972, the order was doubled, bringing the value of the sale to $103 million -- an amount considerably greater than the total value of all UK exports to China in 1971. Much to everyone's surprise, shortly after the first of these twelve aircraft was delivered to CAAC in November 1972, the Chinese again increased their order by an additional eight, two of which will be the new extended-range version, the Super Trident 3B. Yet a fourth order for 15 Trident 2Es was placed in December 1973 with deliveries to begin in the autumn of 1975, bringing the total number of Tridents ordered to 35.

For the British aircraft industry, facing an uncertain future, the large Trident sale, valued at $288 million, is a matter of considerable moment; the Trident production line at Hatfield, which would otherwise almost certainly have been shut down, is guaranteed work at least through 1976, when Hawker Siddeley will be able to make an orderly transition to production of its new venture, the HS 146 feeder liner jet transport. But most important, as a result of the mutual confidence and close working relationship that Hawker Siddeley and especially Rolls Royce have built up with the Chinese, a continuing dialogue has developed concerning long-range plans for the transfer of technology. The most significant outgrowth of this, Chinese efforts to obtain Rolls Royce Spey engine technology under license, is discussed below.*

For CAAC's domestic routes, the gradual acquisition of the Trident fleet will mean at least a doubling of available seat-miles by 1975, and probably a quadrupling by the end of 1977. Getting a respectable utilization rate out of that fleet, however -- say, an average of six to eight hours per day -- will require a major upgrading of China's primitive civil aviation "system" and a revamping of CAAC's present phlegmatic operating procedures.** The leisurely pace at which the

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*See below, pp. 57-60.

**All indications, including especially the remarkably small average number of CAAC flights per day, point to an exceedingly low aircraft utilization rate at present.

Tridents are to be delivered should make it possible for China to undertake such an upgrading and revamping, but large expenditures on navaids, air traffic control, and ground facilities will be necessary.

For its international routes, the most spectacular aircraft purchase that CAAC has made came in September 1972 when the Chinese concluded a widely publicized contract with the Boeing Company for ten aircraft: four Boeing 707-320B passenger and six 707-320C convertible passenger-cargo transports, to be delivered at a rate of one per month between mid-1973 and the early summer of 1974. In addition, United Aircraft Corporation obtained a supplementary $20 million contract for the sale of 40 spare Pratt & Whitney JT3D turbofan engines -- compared with normal international aviation practice, where the customary spares ratio is only about 25 percent, this 100 percent spares ratio for the ten-unit 707 fleet is unusually high. However, a large buy of spare engines appears to be standard Chinese practice, adopted, presumably, to avoid a recurrence of the spares crunch the Chinese suffered in the years immediately following the Sino-Soviet split. The Vickers Viscount sale to China in December 1961, for example, included what was in Vickers' experience an unprecedentedly large ratio of spares to whole aircraft. The same was true in each of the Trident orders of 1971-1973. The Chinese policy of acquiring a "safe" reserve of airframe and engine spares is even more zealously followed in the case of purchases from the Soviet Union. The May 1964 CAAC order for five Il-18s involved no less than 30 extra engines, for a spares ratio of 150 percent. The 1971 acquisitions of two Il-62s, six An-24s, and three heavy-lift Mil Mi-6 helicopters also quite evidently included a very large buy of spares.*
Clearly, the Chinese are determined to guard against any possible future interruption of trade.

Probably the most unexpected aircraft "purchase" the Chinese have made -- and the least likely to be consummated -- was a "preliminary

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*The cost of the eleven aircraft could hardly have exceeded $20 million, but the value of all air transport equipment obtained from the Soviet Union in that year was $33.4 million (see Table 3, p. 39).

purchase order" for three* Anglo-French Concorde supersonic transports announced in July 1972 after two months of intensive negotiations. What motivated the Chinese to move in this costly and super-sophisticated direction, and whether they were in fact serious, is still very much a subject of conjecture, and there is very little factual information to draw on for an answer. How much of a financial commitment did the Chinese in fact make and how carefully did they consider the economics of supersonic air carriage in negotiating for the Concorde? After all, the purchase of three Concordes, complete with spare engines, airframe and avionics spares, specialized ground servicing equipment and simulators would involve a package price of close to $200 million,** a not inconsiderable sum when compared to the modest overall value of CAAC's existing civil aircraft fleet. Also the Chinese could not have been oblivious of the notoriously high anticipated cost of operating the aircraft. How concerned were they about these costs?

Unfortunately, what transpired in the negotiations with CAAC on the Concorde has been kept a jealously guarded secret by Aerospatiale, the firm that did most of the negotiating for the Anglo-French consortium. But we may conjecture on the basis of Chinese behavior in earlier negotiations -- on the Viscounts in 1961 and on the Tridents and Boeings in 1971-1972 -- that their interest was focused much more on the *technical* characteristics of the aircraft (flyability, airframe durability, engine time between overhauls, takeoff and landing weights and roll distances, landing gear footprint pressures, ease of maintenance, and so forth) than on *operational* factors relating to commercial productivity (operating costs, guaranteed payloads on specified routes, optimal stage lengths, scheduling flexibility, and so forth). It has been consistently the experience of Western aircraft sellers that the Chinese are far more interested in the technology of the aircraft they are considering than

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*The initial order for two was raised to three within a few weeks of the first announcement.

**Assuming a then-quoted Concorde price of $36 million per aircraft.

in any questions of operating efficiency, even to the point of refusing to discuss the stage lengths over which the aircraft might be used, their likely utilization rates, potential load factors, specific route structures, and similar matters. In part, of course, this reticence can be explained by the passion for secrecy the Chinese persistently display on anything concerning their own plans and operations. In part, however, it no doubt also reflects a real unconcern and inexperience with any kind of cost-effectiveness approach to their civil air operations. CAAC officials, in personal conversation, freely admit that their airline is an unprofitable venture. Their way of operating is rudimentary -- unreliable schedules, low utilization of aircraft, frequent cancellations; they have burdened themselves with a cumbersomely hybrid fleet -- a dozen different aircraft types drawn from seven different aircraft producers in four different countries; and many of their equipment choices have been unfortunate -- the notoriously uneconomic Soviet Il-18s and the clumsy Il-62s being the two most glaring examples.* All this reflects a legacy of low priorities for aeronautics, a consequent lack of professionalism, and certainly a dominance in China's air transportation of political over economic considerations.

But if questions of cost and operating efficiency do not loom large in CAAC's aircraft procurement decisions, what considerations might have motivated the Concorde "purchase"? At least three possible explanations come to mind:

1. The "preliminary purchase order" -- which is little more than an option to buy -- may not have been intended by the Chinese as a serious procurement decision, but rather as a political gesture helpful to the British and French, whose Concorde sales campaign was already in dire straits. The British and French were bound to welcome any sales contract, however tenuous, as at least temporarily lightening the burden of

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*Some might argue that the British Tridents were also a questionable choice, but their disappointing sales record was much more a result of marketing problems than of any lack of operating economy or effectiveness. (Total Trident sales and orders by the end of 1973 numbered only 117 -- more than half of which to British Airways -- while its closest competitor, the Boeing 727, passed the 1,000-mark at midyear.)

their albatross. For the Chinese, the gesture would serve to strengthen their burgeoning relationship with the Anglo-French aircraft industry at very low cost to themselves. Given the weak Aerospatiale-BAC bargaining position on the Concorde, the consortium was hardly likely to be able to extract any major financial commitment from the Chinese or to attach any significant penalties to a cancellation of the order.

2. To the extent that the order *was* a serious, though tentative, procurement decision, its primary motivation may have been a desire not to continue to be outclassed in international aviation by the Soviet Union and the West. By 1972 it must have seemed inevitable to the Chinese that, within a few years, Western European airlines (using the Concorde) and the USSR's Aeroflot (using the Tupolev Tu-144) would be offering supersonic service on key Asia-to-Europe routes. Given China's sensitivity to matters of international status and prestige, the prospect of CAAC having nothing more exciting than the familiar Boeing 707 may well have made the Chinese feel more than a little *déclassé*. Signing the preliminary purchase order was a low-risk way for CAAC to guard against that contingency and assure itself of an early delivery position if a lively demand for the Concorde were in fact to develop.

3. Conceivably, the object of the purchase was not so much to acquire the most modern aircraft for CAAC's fleet, but to gain access to the very advanced aerodynamic, structural, and propulsion technology embodied in the aircraft, with a view to advancing China's own aircraft manufacturing capabilities. Ordering three of the costly aircraft for delivery in 1977 is hardly an expeditious or economical way of acquiring technology, but the negotiations alone would yield a great quantity of technical information and the purchase order would open the door wide to follow-up plant visits, demonstration flights, and other forms of technical cooperation.

Probably some elements of all three of the foregoing considerations were involved in the Concorde decision. The last of these, China's technology extraction aims, raises some interesting questions that strike at the heart of the present study and that deserve more detailed discussion.

IV. AIRCRAFT ACQUISITION AND TECHNOLOGY EXTRACTION

How significant are these aircraft acquisitions to the Chinese as a way of advancing their own design and manufacturing capabilities? Have they in fact seriously sought to "extract" technology from these acquisitions, and how "extractable" is technology by this means? All indications point to the conclusion that the Chinese in the post-Soviet period -- in spite of their keen interest in aircraft technology -- have made only a very limited effort to exploit their aircraft purchases to enhance their own design and production know-how. They recognize that prototype copying is a sluggish and unrewarding process under the best of circumstances, and that, where the level of technology is as low as it has been in the Chinese aircraft industry, it would be particularly difficult for them to absorb the very advanced technology embodied in their modern aircraft imports.

HOW MUCH DO THE CHINESE LEARN?

It seems quite clear that the Chinese purchases of foreign aircraft and engines during the 1960s and early 1970s were aimed at expanding and upgrading their air transport fleet and not at enhancing their manufacturing technology. The aircraft were purchased for the purpose of end-use, not as prototypes to be copied or adapted to China's own aircraft production. No doubt the airframes, engines, and components were carefully dissected and studied, and technical lessons were drawn from them, but the evidence suggests that no real effort was made to copy-produce them. For example, the Soviet Il-18 turboprops have been in the CAAC fleet since 1960 and the Vickers Viscounts since 1963, but the Il-18s apparently still go back to the Ilyushin plant in Moscow for overhaul and, while CAAC evidently does its own airframe and engine major maintenance on its Viscounts, Rolls Royce has been supplying CAAC with a flow of replacement engines over the years. In other words, the Chinese have not attempted to copy-produce their own versions of these airframes or engines. They have yet to manufacture their first turboprop aircraft, and they have not so far produced a civil aircraft turbine engine of any kind.

This is not to say that the Chinese have not exploited the technological intelligence opportunities afforded them by the aircraft acquisition process. They certainly have, and with considerable finesse at that. In this field as in many others, they are most thorough and systematic in extracting a maximum of technical information from their innumerable discussions and negotiations with Western aircraft manufacturers, their many plant visits, their attendance at air shows and demonstration flights, from the specialized technical training that their flight, maintenance, and ground crews receive as part of any purchase agreement, and from the vast quantities of technical documentation that is lavished upon them by hopeful Western sellers. But while all this sounds impressive, the amount of technical knowledge that can be thus acquired is really quite limited. Although it keeps the Chinese in touch with international technological trends, is useful as general background education, and is essential for operational familiarization, it is not particularly helpful in advancing their own ability to design, adapt, or manufacture.

Every major aircraft purchase is, of course, accompanied by the acquisition of some technical documentation, some training of personnel, and some access for Chinese technicians to a foreign production plant. But all of this is quite carefully negotiated and circumscribed.

The Boeing purchase provides a good example. Along with the ten 707s came the essential aircraft performance, maintenance, and operations documents, such as the Maintenance and Instructions Manual, the Pilot Operations Manual, spare parts catalogues, and similar materials required for flying the aircraft and keeping them in operating condition. But this has precious little to do with production technology. For that, what counts are blueprints, manufacturing drawings, descriptions and specifications of materials, test and laboratory reports, strength calculations, reports of wind tunnel tests, aerodynamic and stability calculations, and process specifications, to say nothing of templates, dies, patterns, jigs, instruments, the tools and machinery actually used in production. Most important, of course, is the knowledge and experience in the heads of the design engineers who created the aircraft in the

first place. Needless to say, none of this was included in any purchase agreement. Training was similarly limited to operational matters: 60 days of flight training for a small number of Chinese instructor crews, and ground crew training on servicing and maintenance of systems and structure, both given at Boeing-Seattle; an eleven-week engine overhaul course for 18 Chinese engineers, given at Pratt & Whitney-Hartford; and an avionics maintenance course given at Bendix-Fort Lauderdale. In addition, the Chinese airline CAAC, like all aircraft-purchasing carriers, was permitted inspection teams ("resident representatives") at both Seattle and Hartford, to sign off on major airframe and engine construction features and to approve final test runs. China sent eleven such representatives to Boeing and four to Pratt & Whitney. They work closely with the manufacturers' quality control teams to assure compliance with technical and performance specifications set forth in the purchase agreement. What they have access to varies, but even where they have considerable freedom to move about the plant and observe techniques and processes, their opportunities for acquiring design or production technology of any consequence are severely limited. Data on critical design features, such as the airfoil profile, wing bending moment, nacelle inlet design, are well-guarded proprietary secrets which manufacturers reveal to no one except under carefully specified technology or production licensing arrangements. But such arrangements have been deliberately shunned by the Chinese, at least until the recently initiated Spey engine negotiations with Rolls Royce (1971) Ltd.*

It should be noted that Chinese ambivalence about foreign technology and expertise, i.e., their determination to achieve "self-reliance" and to limit the foreign role, stands in sharp contrast to the Soviet policy on technology acquisition at a roughly comparable stage in their development, namely in the early 1930s. Far from having any inhibitions about foreign know-how, the Russians wheedled, borrowed, and purchased technology from the West on a massive scale.** They developed an unbelievably

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*See below, pp. 57-60.

**See R. A. Kilmarx, *A History of Soviet Airpower*, Praeger, New York, 1962, p. 163.

thorough technical dragnet for acquiring knowledge about Western technical processes, and for acquiring prototypes of the most advanced equipment; they undertook careful comparative technical studies of alternative designs, and hired foreign engineers to help them select the best designs -- and the best design would then become the "standard" and be duplicated and mass produced. To assist actual production, the Russians concluded technical assistance or production licensing agreements with Western firms in order to obtain samples of the products to be copied, production drawings, process equipment, and engineers to supervise plant layout and assembly. In aircraft, the scope and significance of these technology transfer agreements was striking indeed. As described by Sutton,* technology was obtained from U.S. firms

> for Vultee attack bombers, the Consolidated Catalina, Martin Ocean flying boat and bombers, Republic and Sikorsky amphibians, Seversky amphibians and bombers, Douglas DC-2 and DC-3 transports and the Douglas flying boat. Italy was also an important supplier, with Savoia and Macchi technical assistance for flying boats and Isacco assistance for helicopters. French manufacturers supplied the Potez design. British manufacturers supplied the Fairey model and flying boats. Czech manufacturers supplied bombers. German assistance was forthcoming in the form of Heinkel and Dornier designs in the early 1930s and also under the Nazi-Soviet pact of 1939.

Some of these agreements were exceedingly comprehensive. The Douglas DC-3 transfer, for example, covered not only complete sets of aircraft in subassembly, process specifications and drawings, but also a full set of 6,485 templates, 350 dies, wood and plaster patterns, and 50 complete sets of raw materials (castings, forgings, extrusions, and so forth). As Sutton puts it, "it was rather like supplying 50 toy construction sets; the Russian plant engineers needed only to follow the drawings and put the pieces together."** And yet it took them almost four years to get their first Soviet-produced DC-3 off the assembly line.

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*Antony C. Sutton, *Western Technology and Soviet Economic Development, 1930 to 1945*, Hoover Institution Press, Stanford, 1971, p. 220.

**Ibid., p. 233.

The point of this digression is simply to underline the contrast between the Soviet Union's uninhibited "open arms" attitude toward Western technology and the self-protective "arm's length" Chinese relationship to foreign expertise. The Soviet approach gave them some immediate technological benefits and enabled them, in time, to become very adept at prototype copying.* Their independent design skills, however, evolved only very slowly. The Chinese approach, on the other hand, is certainly not aimed at achieving rapid short-run technological gains. Whether it is a more effective way of promoting design creativity and self-confidence in the long run is debatable. We shall return to this question in the final section of this Report.

WHAT BENEFIT FROM PROTOTYPES?

There is a widespread belief that a technically backward country, bent upon rapid modernization, can achieve major gains in design engineering and production technology by a deliberate policy of "prototype-copying" -- systematically acquiring samples of advanced equipment, one or two of a kind, carefully dissecting and analyzing them and, through a kind of reverse engineering, then proceed to duplicate them. The process, however, is far more laborious and far less rewarding than might first appear. Even the relatively simple matter of hand-fashioning or custom-building a single duplicate is arduous enough. Without access to the design or manufacturing data, the copier must recreate the basic blueprints, the detailed engineering drawings, and, most important, the materials specifications. With something as complex and demanding as a modern aircraft, devising adequate materials specifications requires sophisticated metallurgical analysis, testing, and experimentation; even then the level of fabricating technique attained by the copier may not be adequate to duplicate the metal casting, forming, shaping, joining, and finishing operations well enough to achieve the necessary endurances, tolerances, dimensional accuracies, and critical weight distributions.

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*The rapidity (three years) with which the Russians copied the Boeing B-29 Superfortress to create the Tupolev Tu-4 bomber and the Tu-70 transport on the basis of two prototypes that fell into their hands in 1944 must be attributed at least in part to their many years of experience as assiduous copiers. (For a detailed account, see *Boeing Magazine*, February 1958.)

The task becomes even more trying when the objective is not merely to fashion a single duplicate, but to achieve a series production run. Large-scale production imposes the additional requirements of design standardization to achieve perfect interchangeability of parts and components; it also involves production tooling, plant layout, materials and work scheduling, and quality control. Again, without assistance from the originator, the copier's task is formidable and time-consuming. The prototype merely reveals *what* was produced; it does not reveal *how* it was produced.

And that raises the second major limitation: When the copier has finally succeeded in series-manufacturing the aircraft, he has merely demonstrated that, given time and effort, he can slavishly copy an existing design. He has not greatly advanced his ability to design on his own. The prototype merely reveals the final result of the designer's choices; it does not explain the rationale of these choices. Every major design feature -- wing shape, tail structure, rudder control surface -- is the outcome of a very large number of engineering compromises or trade-offs, the results of stress calculations, laboratory experiments, aerodynamic tests, and so forth. "Understanding" the design, so that the copier can ultimately improve upon it, means knowing *why* these compromises were made and *how* the trade-offs were arrived at. The copier cannot learn this from studying the finished prototype. He must essentially retrace or reproduce the original designer's calculations and investigations. This is relatively easy if the copier is willing and able to obtain the original designer's assistance -- his data and his experience. But for the Chinese the problem is far more difficult, for they have systematically rejected such assistance throughout the post-Soviet period. Just how difficult the problem is will depend in good part on the level of design experience and production know-how that the copier already possesses, i.e., the size of the technological gap that separates him from the originator. When the Chinese recreated the Tu-16 and the MiG-21 in the mid-sixties, this gap was quite large, but still bridgeable, though it obviously required considerable time and effort. Since then, however, very little discernible progress has been made in China, while in the

industrialized countries aeronautical technology has advanced dramatically. By now, therefore, the gap has become abysmal, and it seems most unlikely that the Chinese could close it, even with a massive effort, if they tried to do it completely on their own by prototype-copying and gradual self-improvement.

HOW LARGE A GAP?

China's aircraft manufacturing technology today is at least twenty years behind the West. That, in any event, is the forthright judgment of the Chinese themselves, as reported by British aeronautical experts who have had the longest association with the Chinese. What the Chinese mean by "at least twenty years behind" is that they see their present technical-industrial ability to produce aircraft as roughly comparable to that of the United States, Western Europe, and the USSR in the early and mid-fifties. Moreover, the Chinese are reportedly intensely dissatisfied with the qualitative attainments of their aircraft industry, and chagrined that their more recent efforts in fighter and bomber development have suffered a succession of setbacks and failures. It is worth asking what evidence there is to support such assessments.

Unfortunately, there is precious little firsthand experience with Chinese-built aircraft outside of China. The Pakistani Air Force is the only accessible group whose experience can be studied; it has had substantial exposure over a period of years to at least one Chinese-built model, the MiG-19/F-6 -- Pakistan is estimated to have seven squadrons (112 aircraft) in its air order of battle.

How do the Pakistanis regard these Chinese-built fighters? Given their irridentist rivalry with India, whose Air Force sports the more sophisticated MiG-21, one would expect the Pakistanis to be strongly defensive of their Chinese fighters. In fact, however, their assessment is highly ambivalent. On the one hand, they consider the airplane to be relatively simply but solidly put together as regards technique and quality of workmanship. As to performance, they rate the plane highly in its primary intended role as a day interceptor. In a clean configuration, i.e., without external appendages, it can, they claim, outmaneuver

and even outclimb such more advanced fighters as the MiG-21, and the Mirage III, and they assert that, during the India-Pakistan war, it accounted for several MiG-21 kills.* On the other hand, they are much less impressed with many of its design characteristics. It has an extremely limited range and is therefore not a versatile fighter -- it is unsatisfactory in a ground attack or close air support role. Its useful service life is very short: after 300 hours of flying time, the aircraft must be turned back to the Chinese, presumably for major overhaul -- a requirement with which the Pakistanis do not always comply. They consider the cockpit layout primitive and confusing compared to Western aircraft with which the Pakistani Air Force was brought up. Unlike Soviet design, which stresses good accessibility of engines and components, the Chinese MiG-19 must be arduously disassembled for routine maintenance and replacement of critical parts. In short, while the Pakistanis have a high regard for its performance in its principal intended role, they admit that the aircraft has design and functional shortcomings which render it less than satisfactory as an all-around flyable, maintainable, durable weapons platform.

The MiG-19 is, of course, the earliest of the fully-Chinese produced "modern" fighters, but also the one that has been turned out in the largest numbers. Regrettably, we have no comparable firsthand observations, say, on the Chinese versions of the MiG-21 or the Tu-16 bomber. But something more general, which would seem to lend credibility to the alleged Chinese assessment of "twenty years behind," can be said about these three models. What level of technology do these models represent?

All three of these aircraft entered series production in the Soviet Union in the early and mid-fifties. They represent approximately the level of airframe manufacturing technology typified by the U.S. military aircraft of the forties and early fifties -- the B-50, F-86, F-100, and F-104. In their propulsion systems, the Klimov RD-9B that powers

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*Those kills, however, may have been as much a function of the American-made air-to-air missiles with which it was armed as of any performance superiority inherent in the aircraft. It should also be noted that published Indian accounts of their MiG-21FL duels with Pakistani MiG-19s and F-104s make no mention of any downings of Indian aircraft by the Pakistanis. (See Pushpindra Chopra, "India and the MiG-21," in *USAF Fighter Weapons Review*, Spring 1974, pp. 18-26.)

the MiG-19, and the Tumanskii R-37F that propels the MiG-21 are closely comparable in performance and technological level to the Curtiss Wright J-65 and the General Electric J-79, respectively. These went into service in the years 1954-1956, though the axial flow dual-rotor compressor design incorporated in the Tumanskii engine was pioneered earlier by Pratt & Whitney and introduced in their highly successful J-57 in 1952. The Mikulin RD-3M that powers the Tu-16 has no close U.S. parallel. It is a classic example of the Soviet emphasis, in the 1950s, on high thrust, large volume engines, at the cost of high fuel consumption rates and high specific weights. The most nearly equivalent U.S. engine in terms of thrust and size is the Pratt & Whitney J-75, which did not enter service until 1957. But it has far better engine specifics (weight and fuel consumption) than the Mikulin engine, and a much higher design static pressure ratio. On balance, therefore, it would be fair to characterize the Mikulin engine as also by Western standards an early 1950s engine.

Alexander and Nelson, in a Rand study of U.S. turbine engine development,* divided the thirty-year history of that development into seven periods or generations, on the basis of specific technological advancements or events. These included such qualitative changes as the replacement of centrifugal compressors with axial flow compressors, the transition from uncooled to cooled turbines, the advance from single-design-point to multidesign-point engines, the displacement of aluminum and conventional steel by titanium and super alloys, the progression of engine type from turbojet to turboprop to turbofan, and the increase in aircraft speed from subsonic through Mach 3. These and other technological advances, and the turbine engines that first incorporated them, were

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*Arthur Alexander and J. R. Nelson, *Measuring Technological Change: Aircraft Turbine Engines*, The Rand Corporation, R-1017-ARPA/PR, May 1972, especially pp. 11-19. The study includes a detailed, analytic comparison of U.S. and Soviet turbine engine development. See also Robert Perry, *Comparisons of Soviet and U.S. Technology*, The Rand Corporation, R-827-PR, June 1973, especially pp. 14-23 and p. 32; Robert Shishko, *Technological Change Through Product Improvement in Aircraft Turbine Engines*, The Rand Corporation, R-1061-PR, May 1973, especially pp. 69-75. The discussion here draws heavily on these analyses.

arranged chronologically into seven generational periods. Looking at that tabulation, we find that the closest U.S. equivalents (J-65, J-79, and J-57) of the three Soviet engines we have discussed fall in the second and third generation of U.S. turbojet engines, the engines of the early and mid-1950s. In other words, if these three Soviet engines adequately reflect the present level of Chinese manufacturing technology -- and all indications are that they do -- then the Chinese are indeed almost twenty years behind.

Obviously twenty years behind does not mean that it will take China twenty years to catch up. The catch-up period could be much shorter, as will be shown below. Also, it should be noted that any "years behind" judgment is bound to be imprecise, since the concept of an attained "technological level" is necessarily an amalgam of unequal competences and attainments within and among many different spheres -- design know-how, fabricating skills, machining precision, materials applications, and so forth. For example, in the sphere of jet engine design, the Chinese are much further along in the compressor stage than in the turbine stage. This is simply because they have inherited the product of Soviet designers who concentrated in the early fifties on maximizing the airflow capability of the compressor sections and paid relatively less attention to the turbine sections. Western designers, by contrast, tended to give more emphasis to the "hot" sections and to developing exotic heat-resistant materials as the preferred means of obtaining improved engine performance. By now, of course, these disparities between the Soviet Union and the West have evened out, and striking advances have been made by both, in all stages of the turbine engine. These advances have left China far behind.

A list of the more important design and production innovations that China has yet to master would have to include the following:

- High strength titanium replacing aluminum in cool sections
- Higher strength super alloys for the hot sections
- The variable stator (vanes) single spool compressor
- The air-cooled turbine designed for Mach 3

- o Cooled turbine stator and rotor parts
- o The transonic compressor
- o The efficient turbofan for supersonic flight
- o The high bypass turbofan for subsonic flight
- o Small, lightweight engines
- o The three-spool rotor
- o New composite materials

These and other advances have resulted not only in much higher performance, but also in the greater reliability and durability of the turbine engines currently produced in the West.

WHAT GAINS FROM FUTURE TECHNOLOGY IMPORTS?

Within the past year or so, the Chinese have begun to move seriously toward narrowing the gap in aeronautical technology. The most significant move they have made so far was to open negotiations with Rolls Royce, with whom they have had a highly satisfactory relationship dating back to the 1961 purchase of the Vickers Viscount (powered by the remarkably successful Rolls Royce Dart engine). The details of the negotiations are a closely-held trade secret, but knowledgeable British industry sources and press reports* indicate that the Chinese seek to acquire license production rights for at least two of the Rolls Royce Spey turbofan engine family -- the civil Spey Mark 511/512 series that powers the Hawker Siddeley Trident and the BAC-111, and the military Spey Mark 202 that powers the British version of the F-4 Phantom fighter. The latter is a particularly "hot" engine in that it has a sequenced afterburner which augments the basic thrust of the engine by some 75 percent (from 12,000 to 21,000 lb). Moreover, the Chinese are seeking more than normal commercial license rights to reproduce these two engine models in China. They want, in addition, to be free to develop these models further on their own in any way they choose, without any restriction imposed by the licensor.

*See, for example, *Aviation Week and Space Technology*, October 29, 1973, p. 20; *The Financial Times* (of London), October 1, 1973, and November 22, 1973.

How important a gain in technology would this engine represent for the Chinese? Table 4 seeks to put this gain in perspective. It compares the three currently produced Chinese turbojet engines with the Rolls Royce Spey turbofan technology now under negotiation, and with the most advanced high bypass ratio commercial turbofans now in production in the United States and Britain. In terms of the generally accepted critical performance indicators -- turbine inlet temperature, compressor pressure ratio, thrust-to-weight ratio, and specific fuel consumption, the current Chinese engines represent the second and third generation technological level of the early and mid-1950s, as we have already noted above. The Spey, however, falls in the fourth and fifth generation turbofan era of the early 1960s. Thus by acquiring the Spey technology, the Chinese would be propelled in relatively short order, ten years forward. While this would still leave them ten years behind the most advanced high-compression, low fuel consumption engines that now power the new wide-bodied jets in the West (as represented by the Pratt & Whitney JT9D or Rolls Royce RB211 in the last column of Table 4), the ten-year jump would still represent a very significant "leap forward" for the Chinese.

Such a ten-year leap could not, of course, be achieved in a single bound. It would require a considerable Chinese investment in training and facilities, and it would take a substantial period of time to translate the technology purchase contract into actual deliveries of plant and equipment and to transform drawings, specifications, and advice into actual production of engines. The length of the gestation period would depend heavily on the comprehensiveness of the technology transfer and the way it was done. If the Chinese were to allow Rolls Royce to provide a complete package, including an initial flow of engines and a phased program for transferring the capability to produce them -- providing engineering drawings, production equipment, critical materials, and components as well as technical supervision and training -- the period might be no longer than two-to-three years. If, on the other hand, the Chinese were to insist on strict adherence to the tenets of "self-reliance" and severely limit the scope and intimacy of the Rolls Royce relationship,

Table 4

CHINA'S TECHNOLOGICAL LEVEL: AIRCRAFT TURBINE ENGINES

Performance Indicators	Technological Era: Early 1950s — Current Chinese Turbojets (Soviet Derived): Tu-16/RD3M (No U.S. Equivalent)	MiG-19/RD9B (U.S. Equiv: CW J65)	MiG-21/R37F (U.S. Equiv: PW J57/GE J79)	Early 1960s: Rolls Royce Spey Technology Acquisition under Discussion	Early 1970s: Current U.S.-U.K. Technology PW JT9D/RR RB211
Turbine Inlet Temperature (°F)	1,600	1,650	1,700	2,000	2,300 +
Maximum Pressure Ratio	6	7	9	20	25
Thrust-to-Weight Ratio	4	5	5	5	6 +
Specific Fuel Consumption (lb/hr/lb thrust)	0.9	0.9	0.9	0.52	0.35

the gestation period would be very much longer. Assuming that the Chinese feel some sense of urgency, because of their need for a more advanced interceptor and close air support fighter-bomber, the probable and logical route for them to follow would be the former, the comprehensive package approach. It would essentially repeat the very successful USSR-to-China transfer experience of the mid-fifties that permitted the Chinese to progress rapidly from assembly of "knockdowns" to co-production of components, to manufacture of complete engines. (See above, pp. 10-11.) Such an approach would tend to maximize the benefit they could extract from the transfer and to shorten the gestation period. It would, however, involve a political cost: the principle of "self-reliance" in its most unqualified form would be impaired. But the impairment need not be large. The number of essential Rolls Royce engineers providing advice, supervision, and training could be kept small and their presence low-profile. The period of their stay, however, could not be kept short, if the Chinese really wished to use Rolls Royce's immense design experience to benefit their own design technology. Ideally, the relationship should be of indefinite duration. It should not be limited to a few years and to a single technology, but, once the Spey technology had been mastered, should extend to follow-on technologies of a more advanced level, say, the promising Mark 512 improvement program now under way at Rolls Royce, or even the very advanced RB211. In this way, the momentum of the effort would continue beyond the initial leap, and China's independent design and manufacturing capabilities would grow apace. Catching up with the West would then become an achievable goal.

The obstacles to establishing such a relationship no longer seem insurmountable. The Chinese have already begun to relax their strictures against the use of foreign experts on site. Some of the major whole plant purchases made by the Chinese in 1973 and early 1974 have included, for the first time, provisions for large numbers of foreign engineers to

supervise plant assembly and to monitor run-in.* The trend in this as in other aspects of China's technology import policy is toward further liberalization, but at this stage the issue is clearly still a politically sensitive one.

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*For example, the $34 million urea plant complex purchased from Kellogg Continental will include engineering assistance, to be provided by small contingents of Dutch State Mines technicians who will accompany each of the three plants as they are delivered. The huge cold-strip steel rolling mill purchased from Siemag and Demag of West Germany in March 1974 requires these firms to send some 230 German engineers to Wuhan over a period of three years (1975-1977) to advise on its construction. Similarly, the even larger hot-strip mill purchased from the Japanese Nippon Steel consortium in May 1974 calls for some 350 Japanese technicians to live at the same Wuhan site over a similar period.

V. CURRENT DEVELOPMENTS: QUESTIONS AND PUZZLES

Fairly clear-cut patterns and trends emerge from the information and observations on which this study of China's evolving aircraft and technology acquisition policy is based. But the picture is far from complete. Many questions remain unanswered, and some additional facts and indications hint at future developments. Some of these seem worth discussing.

SLOW ENTRY INTO SERVICE

One of the puzzling aspects of China's current expansion of air transportation is how slowly the Chinese airline CAAC is placing its newly-acquired aircraft into service. The PRC acquired traffic rights at a dizzying pace, concluding air agreements with numerous countries during 1972-1973 (see Appendix Tables A-2 and A-3), but until September 1974, the actual utilization of these rights has been virtually zero. Several months earlier, CAAC had taken delivery of the last of the ten Boeing 707 aircraft it had purchased, and yet none of them had been placed into scheduled international service.* A few Boeings were gradually being phased in to the domestic service on the Peking-Shanghai-Canton run, but the much-touted CAAC route to Western Europe had yet to be inaugurated and the Peking-Tokyo route was not opened until September 29. CAAC has also been slow in putting in service the five Il-62s purchased from the Soviet Union and the seven Tridents received on its Hawker Siddeley order of 35. Judging from the published airline schedules of September 1974, the small number of domestic route segments and frequencies shown as jet-serviced could easily have been operated by three or four of the fourteen Ilyushin and Trident jet aircraft then in CAAC's fleet.

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*Two special flights to New York, for high-ranking PRC officials and UN Mission personnel, were, however, made by CAAC in the Spring of 1974, both using the 707 (*The Washington Post*, March 30, 1974).

A lack of trained flight or ground personnel may explain the puzzle. CAAC personnel absorbed very effectively the initial flight and ground crew training provided them by aircraft and engine manufacturers as part of their sales packages, but more advanced kinds of training, such as ditching procedures, require the use of flight simulators. CAAC placed its first order for two sophisticated flight simulators in November 1972,* but delivery was not made until August 1974. It would be consistent with the acute safety-consciousness of the Chinese to postpone initiating international service until the more advanced simulator training could be given.

Another explanation is China's grossly underdeveloped air transport system, and the formidable task CAAC therefore faces in handling the increased volume of passenger and freight traffic that the newly-procured aircraft will generate. All services -- from reservations, ticketing, and ground transportation to air traffic control, meteorological forecasting, and communication -- will have to be greatly expanded. This cannot be done overnight, and some of it requires substantial investments. The problem is particularly acute on the international routes, where CAAC has virtually no preexisting assets to draw on. It will have to develop such things as general agency agreements and spares pooling arrangements with other international carriers, set up regional and local ticket offices, establish a relationship with the International Air Transport Association's London Clearing House, and so forth.** Since the Chinese are notoriously cautious and deliberate in their international

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*One is configured as a Boeing 707, the other as a Trident 2E; both share an advanced visual system that can actually simulate splashdown sounds and water droplets on the windshield.

**For example, the Chinese have no worldwide telecommunications system at their disposal. To gain access to such a system, CAAC signed an agreement with Air France that permits it to use Air France's network abroad in exchange for Air France's using CAAC's facilities within China (*Aviation Week and Space Technology*, May 13, 1974, p. 29). CAAC has also signed an agreement with Pakistan International Airlines (PIA) that permits CAAC to share PIA's servicing facilities throughout the world (*China Trade Report*, May-June 1974, Item 109).

dealings, it is not surprising that these arrangements have taken longer than might have been expected.

OVERHAUL CAPABILITIES

Also uncertain are the extent and quality of Chinese aircraft and engine overhaul capabilities. All China's major aircraft purchases from the West beginning with the Viscount purchase of 1961, have included some training of maintenance and overhaul personnel on aircraft structures and engines. What is called "line maintenance" in the U.S. is, of course, routinely performed by CAAC on all of its aircraft. But just how extensively it can perform major maintenance and complete overhaul is not known. The Soviet aircraft in the CAAC fleet should have posed no problem, since it is general Soviet practice to call for the return of their aircraft to the manufacturing plant in the USSR for overhaul after a specified number of flying hours.* Such provisions for factory overhaul, however, are not normally made for Western-built aircraft, since the arrangement would wreak havoc with utilization rates. Thus there is a question as to how the Chinese will cope with their overhaul problem on the new Boeing and Trident aircraft.

In the Boeing case, the Chinese encouraged the Pratt & Whitney Division of United Aircraft, which manufactures the engines for the 707, to undertake a facility study for a complete overhaul shop, including a test cell and all requisite equipment. That study was submitted to CAAC in the Spring of 1973, but the Chinese have not so far (September 1974) made any move to procure the facilities proposed.

In the Trident case, the Chinese have apparently decided to import the necessary equipment to establish a complete overhaul facility on their own. A special-purpose Chinese mission, the *Trident Spare Parts and Overhaul Purchasing Group*, composed of CAAC and MACHIMPEX**

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*Whether this practice continues to be followed by the Chinese is not altogether clear. One knowledgeable source asserts the CAAC's Soviet-built civil aircraft are now overhauled at Chinese military airfields. (John D. Harbron, "CAAC," in *Flight International*, February 7, 1974, p. 165.)

**MACHIMPEX is the widely-used acronym for the China National Machinery Import and Export Corporation, one of the PRC's eight foreign trade corporations that are responsible for negotiating all of China's foreign trade contracts.

specialists, paid a first reconnaissance visit to British parts and equipment suppliers in July 1974.* As regards the Trident powerplant, the proposed Spey engine technology transfer that is still under negotiation reportedly includes, as a first step, the setting up, in Peking, of a Spey engine overhaul facility.** Such facilities are, of course, quite expensive and a decision to make such an investment would not be taken lightly. Since CAAC has almost three dozen Tridents on order, the fleet will eventually be large enough to make it efficient for CAAC to have its own specialized overhaul facilities. The same does not necessarily hold true for the ten Boeings. In the West, only the largest air carriers perform their own overhauls. The smaller ones find it far more economical to contract out for such services. Continental Airlines, for example, with its fleet of sixteen DC-10s, finds that having all of its overhaul work done by United Airlines at United's huge maintenance base in Los Angeles is far cheaper than doing its own. CAAC would no doubt find the same to be true for its Boeings.

There is some real indication that the Chinese are leaning in this direction, as evidenced by a recent contract between CAAC and MACHIMPEX on the one hand and the Hong Kong Aircraft Engineering Company (HAECO) on the other. The contract calls for the overhaul in Hong Kong during 1974 of three of CAAC's six Viscounts and seven Rolls Royce Dart turboprop engines (an odd number, considering that each Viscount has four Dart engines). Moreover, CAAC officials are reported to have held out the prospect to HAECO that this first contract may be followed by others covering overhaul of some of the newer jets.*** The arrangement would make perfectly good economic sense, but since CAAC has been operating the Viscounts for more than a dozen years, one wonders how thoroughly these aircraft have been overhauled by CAAC in the past. The overhaul area thus remains something of a puzzle.

***China Trade and Economic Newsletter*, No. 225, July 1974.

***Aviation Week and Space Technology*, October 8, 1973, p. 9.

****China Trade Report*, February 1974, Item 11.

LIGHT AIRCRAFT AND HELICOPTERS

Within the past year, the Chinese have given us some tantalizing hints of a burgeoning interest in acquiring small transport aircraft, particularly in the Short Take Off and Landing (STOL) class, and in developing their own capabilities to design and produce such aircraft, to wit:

- In small planes, the Chinese have been eyeing the Britten-Norman "Islander" as a promising candidate for manufacture under license in China.[*] This popular, economical ten-passenger short-hauler would be a considerable improvement over CAAC's obsolescent fleet of Antonov An-2s, a biplane design dating back to the early 1950s.
- A Chinese aviation mission, visiting the Australian Government Aircraft Factories in Melbourne, also expressed a lively interest in the Nomad 24, a 15-passenger STOL transport that has both civil and military applications.[**] The Nomad, which is powered by a GM Allison turboprop engine of 416 shp, is to be one of the principal exhibits at the Australian Trade Fair scheduled to be held in Peking in October 1974.
- The Chinese placed an initial order, in November 1973, for seven JT15-D-1 turbofan engines manufactured by United Aircraft of Canada, Ltd (UACL). In the U.S. these turbofans power the twin-engine, seven-to-eight passenger Cessna Citation 500 series executive jet which boasts an impressive STOL performance. The Chinese indicated to UACL officials that they intend to use these engines to power a light jet transport of their own design.[***]

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[*] *China Trade and Economic Newsletter*, March 1973.

[**] *Aviation Week & Space Technology*, August 6, 1973; p. 9; *Interavia*, January 1974.

[***] *Asia Research Bulletin*, January 31, 1974, p. 2423.

On the helicopter front, the Chinese appear to have even larger ambitions. So far, their production capabilities have been limited to the Mil Mi-4 fourteen-passenger piston-engine helicopter, of which they have perhaps a dozen in civil airline service. They augmented this fleet in 1967, as already indicated,* by a purchase, from Aerospatiale, of fifteen Alouette III (SA.316B) six-passenger helicopters. In addition, in 1972, they acquired three of the huge Soviet Mil Mi-6 heavy general purpose helicopters with their twin Soloviev 5,500 shp turboshaft engines. Whether their 65-passenger capacity is being put to civil or military use is not known. Beginning in 1973, however, the Chinese seemed suddenly to be moving more energetically into the helicopter field, to wit:

- From UACL, again, they purchased six PT6T Twin Pac power plants, each consisting of two PT6 free-shaft turbine engines and a combining gearbox. The Twin Pac is used by Sikorsky in a conversion kit to convert the S-58 helicopter to turbine power (S-58T). The Chinese Mi-4s could be similarly converted. In performance, they are roughly in the same class, though somewhat heavier than, the S-58. If conversion is the intent, the Twin Pac will be quite useful in helping the Chinese experiment with various conversion and other rotary-wing aircraft power plant applications.
- From Aerospatiale, after relatively brief negotiations, they ordered thirteen SA.321 Super-Frelon heavy-lift helicopters. With its three Turbomeca Turmo 3C engines, the Super-Frelon is the heaviest helicopter built in Europe. It is produced both in a general purpose and an Anti-Submarine Warfare (ASW) version. The Chinese purchase involves the general purpose version only.
- Another dual-purpose helicopter has also caught the Chinese eye: the Sikorsky S-61N, an amphibious twin-turbine medium helicopter, which, in a military version, is also used by

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*See above, p. 39.

the U.S. Navy for minesweeping. Negotiations on this purchase, however, have not moved beyond the stage of preliminary talks, and have so far been restricted to the Chinese being provided sales information on the "commercial" version only.*

SCOUTING MILITARY AIRCRAFT

In addition to their burgeoning interest in small STOL transports and helicopters, most of which, with minor modifications, could also be used in military roles, the Chinese have expressed sporadic and discreet interest in strictly military transports and combat aircraft, and have evidently considered outright purchase. Some inquiries may have been little more than exploratory, but in other cases the communication appears to have been more purposeful. The available reports are generally quite imprecise as to the extent of the discussions, how serious they were, and who initiated them. A sampling of these reports may be illustrative:

- A Lockheed marketing/technical team visited the PRC in June 1972 to discuss Lockheed "passenger and cargo aircraft" in response to an invitation by MACHIMPEX. When it became apparent at their first meeting in Peking that the Lockheed group was authorized to make presentations only on its commercial jets and not on its military cargo aircraft, the Chinese seemed visibly disappointed.**
- A Chinese MACHIMPEX mission visited the Shin Meiwa Industry Co. in Kobe, Japan, in May 1973, and examined a four-engine turboprop amphibious flying boat, developed by the Japanese Maritime Self-Defense Force as an Anti-Submarine Warfare aircraft. Discussion, however,

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*_The Washington Post_, January 16, 1974, p. A2.

**The Chinese had previously much admired the Lockheed C-141, when it landed in Peking in February 1972 with President Nixon's advance party, and their interest in this aircraft may have been the real reason for the invitation to Lockheed.

centered on the RS-1 Search and Rescue version of this aircraft.*

- o Another discussion reportedly occurred in the Spring of 1973 between Hawker Siddeley and the Chinese, concerning the HS801 Nimrod Maritime Reconnaissance aircraft (powered by four Rolls Royce Spey engines). Consideration of purchase, however, apparently *excluded* the integral avionics systems.**
- o Discussions also reportedly took place during 1973 between the Chinese and Hawker Siddeley concerning the possible purchase of large quantities (numbers reported were between 200 and 400) of the versatile Harrier, a remarkable vectored thrust VTOL attack-reconnaissance fighter, which the U.S. Marine Corps rates so highly that it has procured it for its own forces.***

There is no evidence that any of these "feelers" and approaches developed into serious negotiations. Nor is it clear that the Chinese have decided to enter into such negotiations. Moreover, there have been no reports of any such feelers since the Fall of 1973.

Clearly, it would be a political act of some consequence for a socialist country to purchase military equipment from a nonsocialist country. A PRC military purchase from a NATO country or from Japan would emit very loud political signals. China's principal adversary, the USSR, would surely view it as extremely provocative, and it is hardly surprising that the Chinese have been very gingerly about their moves in this area. They would not make such a purchase lightly, nor would it be sanctioned by the government of the selling country except under unusual security circumstances and in an "appropriate" larger strategic context, for it would constitute a dramatic departure from the established U.S. and COCOM export control environment. Quite possibly the feelers and

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***Asahi Shimbun*, May 23, 1973; see also *China Trade Report*, May 1973, Item 188.

***Aviation Week & Space Technology*, June 4, 1973, p. 11.

****Interavia*, March 1974, p. 247.

approaches the Chinese have made thus far are largely psychological and preparatory in nature, i.e., aimed at demonstrating that such an option is open to them. And they may be intending to establish contacts and lay the groundwork for possible future transactions that they would conclude only in the event that some threatening political or security contingency should arise.

APPENDIX

Table A-1

CAAC INTERNATIONAL ROUTES, 1950-SEPTEMBER 1974

Service to	Year Begun	Route Flown From	Route Flown To	Present Status and Frequency[a]
USSR	1950	Peking	Chita-Irkutsk	*Discontinued 1965*
	1955	Peking	Irkutsk	Flown once weekly (Wed.)
	1955	Urmuchi	Alma-Ata	*Discontinued 1965*
	1974	Peking	Moscow	To be flown once weekly, beginning date uncertain
Burma	1956	Kunming	Mandalay-Rangoon	Flown once weekly (Mon.) -- intermediate stop at Mandalay dropped 1965
North Vietnam	1956	Nanning	Hanoi	Flown twice weekly (Tues. & Fri.)
Mongolian People's Republic	1958	Peking	Ulan Bator	Flown on nonscheduled basis -- *Discontinued 1969*
North Korea	1959	Peking-Shenyang	Pyongyang	Flown once weekly (Fri.)
Japan	1974	Peking-Shanghai	Tokyo-Osaka	Flown twice weekly (Tues. & Fri.) Flights beyond Tokyo to Canada planned to begin April 1975
France	1974	Peking	Karachi-Paris	To be flown once weekly beginning November 1974

[a]Frequencies as shown in "Air Line Flight Schedule of the General Civil Aviation Administration of China, effective April 1, 1973." Peking, *Jen-min Jih-pao*, March 31, 1973, p. 6; in English: JPRS 58788, April 4, 1973, No. 222 PRC. Information updated from *Official Airline Guide* (International Edition), September 1974.

Table A-2

ROUTES AND RIGHTS GRANTED TO CAAC UNDER PRC AIR AGREEMENTS,[a] 1955-SEPTEMBER 1974

Agreement with	Year Signed	Routes or Rights Granted	Rights and Restrictions
Burma	11/1955	Any point in China-Mandalay-Rangoon	Traffic
Ceylon	3/1959	Any point in China-Colombo	Traffic
Pakistan	8/1963	Any point in China-{Dacca / Islamabad / Karachi}-and beyond	Traffic
Cambodia	11/1963	Any point in China-Phnom Penh	Traffic
Indonesia	11/1964	Any point in China-Rangoon (optional)-Hanoi-Phnom Penh-intermed. points-Medan-Djakarta-beyond	Traffic
UAR	5/1965	--Not known, but includes Cairo and beyond--	Traffic
France	6/1966	Any point in China-point in Pakistan-2 points in Middle and Near East-Cairo-Tirana-Paris-beyond	Traffic
Iraq	11/1969	Any point in China-intermed. points-{Baghdad / Basra}-beyond	Traffic
Albania	3/1972	Any point in China-intermed. points-Tirana and beyond to Western Europe	Traffic
Yugoslavia	4/1972	Any point in China-intermed. points-Belgrade and beyond to Tirana and Western Europe	Traffic
Rumania	4/1972	Any point in China-intermed. points-Bucharest-Belgrade-Tirana and beyond to Western Europe	Traffic
Ethiopia	7/1972	Any point in China-up to three intermed. points-{Asmara / Addis Ababa}-points beyond Ethiopia in Africa	Unlimited traffic rights, excluding cabotage
Afghanistan	7/1972	Any point in China-{Kabul / Kandahar}-and beyond	Traffic
Turkey	9/1972	Istanbul from and to Bucharest	Technical stop -- no traffic rights
Iran	11/1972	Any point in China-{Karachi / Islamabad}-Kandahar-point in Turkey-Bucharest-Belgrade-Tirana	Unlimited traffic rights east of Teheran; traffic rights west of Teheran limited to Tirana; no traffic rights to Bucharest and Belgrade

Agreement with	Year Signed	Routes or Rights Granted	Rights and Restrictions
Italy	1/1973[b]	Any point in China-intermed. points-{Rome Milan}	Traffic
Greece	5/1973	Any point in China-{Karachi Islamabad}-{Kabul Kandahar}- Teheran-{Baghdad Kuwait Damascus Beirut}-{Ankara Istanbul}-Cairo-{Athens Salonika}- and beyond to Europe and North Africa	Traffic
UK	6/1973	Any point in China-intermed. points (excluding Hong Kong)-London	Traffic
Canada	6/1973	Any point in China-Tokyo-Vancouver-Ottawa and beyond	Traffic
Denmark Norway Sweden	6/1973	Not yet determined	
Switzerland	11/1973	Any point in China-3 points in Middle and Near East-2 points in Europe-Zurich & Geneva-Paris-2 points beyond	Traffic
Japan	4/1974	Any point in China-{Tokyo Osaka}-{Vancouver Ottawa 1 other point in N. Am. 4 points in S. America., including Mexico	Traffic
Others[c]	1972-73		

[a]Excluding agreements with USSR and Asian Communist countries. (See Appendix, Table A-3.)

[b]Agreement in principle.

[c]Air agreements in various forms have also been concluded with the following countries: Chile, Gambia, Kuwait, Lebanon, Syria, Zaire.

Table A-3

ROUTES GRANTED TO INTERNATIONAL CARRIERS[a] UNDER PRC AIR AGREEMENTS, 1955-SEPTEMBER 1974

Agreement with	Year Signed	Routes Authorized	Routes Flown (Carrier)	Frequency
Burma	11/1955	Rangoon-Kunming-Canton	None to date	--
Ceylon	3/1959	Colombo-Canton	None to date	--
Laos	1/1962	Vientiane-Kunming-Canton	Planned 11/1974: Vientiane-Hanoi-Canton (Royal Air Lao)	Planned: once weekly
Pakistan	8/1963	Karachi-Dacca-Canton-Shanghai	Karachi-Dacca-Shanghai Dacca-Canton-Shanghai	*Discontinued 1971*
			Karachi-Colombo-Canton-Shanghai	*Discontinued 1/73*
	Revised 1/1973	Karachi / Islamabad -(Northern Route)-Peking-Shanghai	Islamabad-Peking (Pakistan International Airlines)	Twice weekly
Cambodia	11/1963	Phnom Penh-Canton	Phnom Penh-Kunming (Royal Air Cambodge)	*Discontinued 1969*
Indonesia	11/1964	Djakarta via any point to Canton/Shanghai and beyond	Djakarta-Phnom Penh-Canton (Garuda)	*Discontinued 1966*
UAR	5/1965	Cairo-intermed. points unknown-Peking	None to date	--
France	6/1966	Paris-{Athens / Tirana}-Cairo-Teheran-Karachi-{Phnom Penh / Rangoon}-Shanghai	Paris-Athens-Cairo-Karachi-Rangoon-Shanghai	*Discontinued 9/73*
	9/1973	Paris-Athens-Karachi-Peking added	Effective 9/1973: Paris-Athens-Karachi-Peking (Air France)	Twice weekly
Iraq	11/1969	Baghdad-intermed. points-Canton-Shanghai and beyond	None to date (Iraqi Airways)	--
Albania	3/1972	--Not known--	None to date	--
Rumania	4/1972	Bucharest-intermed. points-Peking and beyond	Bucharest-Athens-Teheran-Karachi-Peking (TAROM)	Once weekly
Yugoslavia	4/1972	Belgrade-up to 4 intermed. points-Peking and beyond	None to date (JAT)	--

Agreement with	Year Signed	Routes Authorized	Routes Flown (Carrier)	Frequency
Afghanistan	7/1972	--Not yet determined--	None to date (Aryana)	--
Ethiopia	7/1972	Addis Ababa / Asmara -up to 3 intermed. points -Shanghai-Peking and beyond	Addis Ababa-Bombay-Peking (Ethiopian Airlines)	Twice weekly
Turkey	9/1972	--Unknown--		--
Iran	11/1972	Teheran- Kabul / Bombay / New Delhi -Rangoon- Shanghai-Peking and beyond	Planned 11/1974: Teheran-Peking-Shanghai-Tokyo (Iran Air)	Planned: twice weekly
Italy	1/1973	Rome / Milan -Canton-Shanghai	None to date (Alitalia) (Agreement in principle)	--
Greece	5/1973	Athens-intermed. points to be negotiated-Peking-Shanghai-Canton	None to date (Olympic)	--
Canada	6/1973	Vancouver-Tokyo or other stop in Japan-Peking-Shanghai-beyond	Planned Winter, 1974: Vancouver-Shanghai (CP Air)	Planned: once weekly
UK	6/1973	London-intermed. points in Europe-Middle East-India-Hong Kong-Peking (no traffic rights between Hong Kong and Peking)	None to date (British Airways)	--
Denmark Norway Sweden	6/1973	--Not yet determined--	None to date (SAS)	--
Switzerland	11/1973	Any point in Switzerland-1 point in Europe-4 points in Near, Middle, and Far East-Shanghai-Peking-Tokyo-2 points beyond	Planned April 1975: Geneva / Zurich -Athens-Bombay- Shanghai / Peking	Planned: once weekly
Japan	4/1974	Tokyo-Peking (JAL) / Osaka-Shanghai (All Nippon) - Bombay / N. Delhi -Karachi-Teheran- Cairo / Istanbul -Europe	Effective 9/74: Tokyo-Osaka-Shanghai-Peking (JAL)	Twice weekly

[a]Excluding carriers of adjoining Communist countries. The USSR, North Korea, Mongolia, and North Vietnam have bilaterals with China, but only two are presently flying into China under existing agreements: the USSR's Aeroflot (Moscow-Peking) and North Korea's CAA DPRK (Pyongyang-Peking), each nonstop once weekly.